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A Commercial Airport Noise Environment: Measurement, Prediction and Control

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A Commercial Airport Noise Environment: Measurement, Prediction and Control

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1.0 INTRODUCTION

Approximately 1,100 calibrated tape recordings of commercial jet airplanes were obtained at three observer positions in the vicinity of Seattle-Tacoma International Airport. The purpose was to develop a library of high-quality recordings with no extraneous acoustic interference (trucks, cars, birds, etc.) for subjective acoustic studies. Also, there was interest in sampling the current fleet of commercial jet airplanes, particularly for takeoffs. This collection of airport noise data, which also included other noise pertinent parameters such as slant range and airplane gross weight, provides the data base for this study. The aims of the data presentation summaries and analyses are:

1. Provide a more detailed description of the airplane noise environments to which persons are exposed.
2. Complete noise comparisons among various airplane types in an operational environment as opposed to standardized comparisons utilizing FAR-36 test procedures.
3. Evaluate airplane noise prediction technology for specific airplane types and also for total noise exposure situations.
4. Determine contribution of gross weight and slant range parameters to noise exposure at specific points.
5. Investigate the comparability of the EPNdB engineering calculation procedure and dBA weighting network and the two noise exposure methods (NEF and L_{dn}) which are respectively based on these two procedures.

2.0 METHOD

The three measurement points are shown in figure 1-1 as part of a schematic of Seattle-Tacoma International Airport. There are two parallel runways with runway "B" being the preferential runway for takeoffs to and landings from the south so almost all events for this study involve this longer runway. Since takeoff events are emphasized, reference point for the location of measurement positions is brake release. Two points were located directly under the flight path and designated 3-C for the point close-in to the airport measurement position and 5-C for a point at a greater distance. The sideline position is designated 3-S. Distance from brake release and sideline are:

Measurement Points	Distance from Brake Release	Distance to Sideline
3-C	5.63 Km (3.04 n.miles)	0
3-S	5.42 Km (2.93 n.miles)	0.68 Km (0.37 n.miles)
5-C	9.64 Km (5.21 n.miles)	0

Recordings were obtained during the daytime by a team of four persons. Three workers operated tape recorders at the three measurement points while a fourth worker was utilized as a "spotter" at the airport sideline so as to obtain airplane identification information and to alert those at the recording positions that a takeoff was occurring. This radio contact between the "spotter" at the airport and those operating tape recorders permitted timely operation of the recorders so long duration signals could be obtained. So that a high signal-to-noise ratio would be available for the listening quality recordings, a compressor-

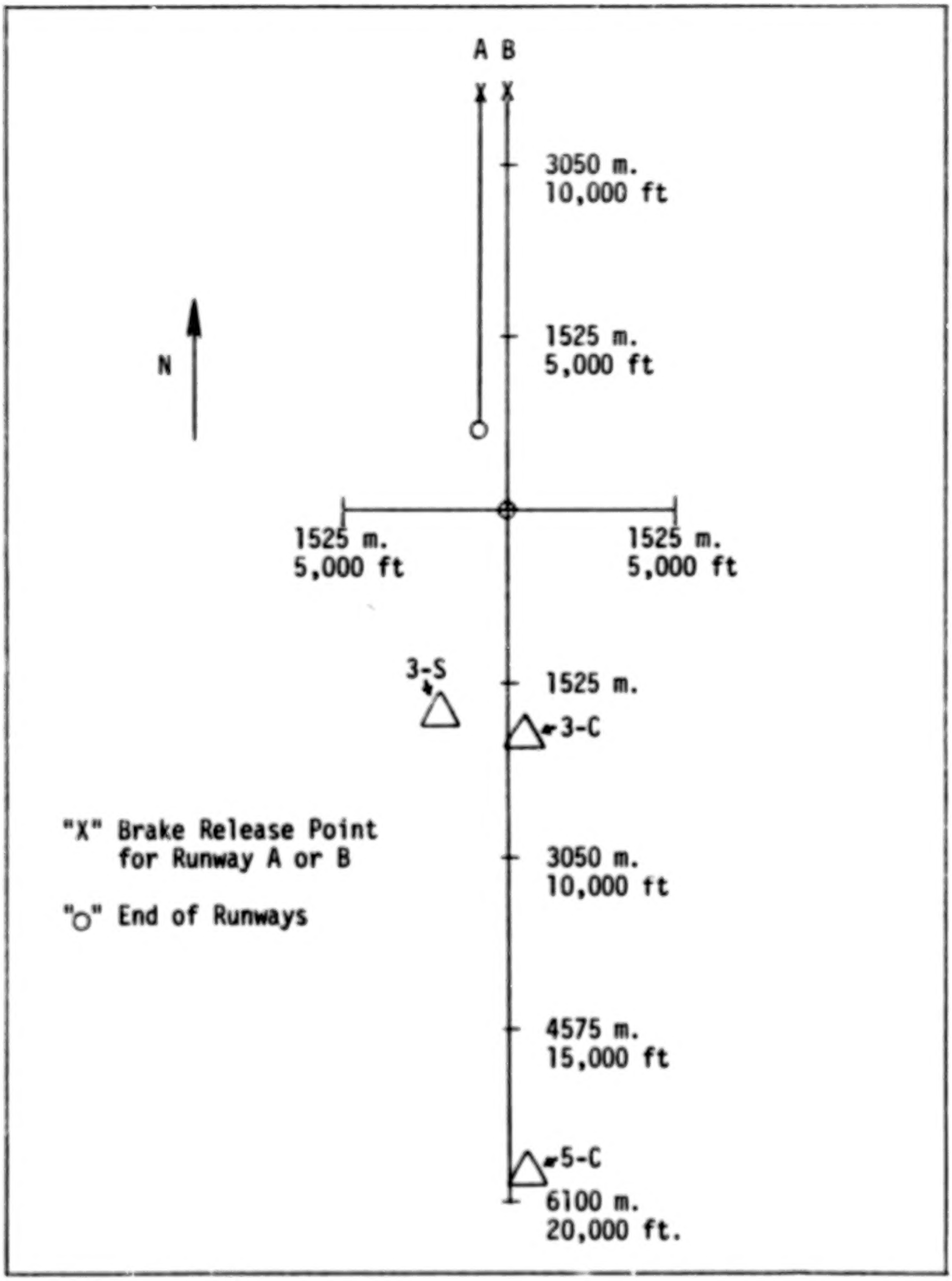


Figure 1-1. Schematic of airport and locations of three measurement points: 3-C, 3-S, & 5-C.

expander approach was used. Signals are compressed or encoded to half their dynamic range and then decoded for analysis or playback. Slant range data were obtained by photogrammetry which was performed by the three tape recorder operators.

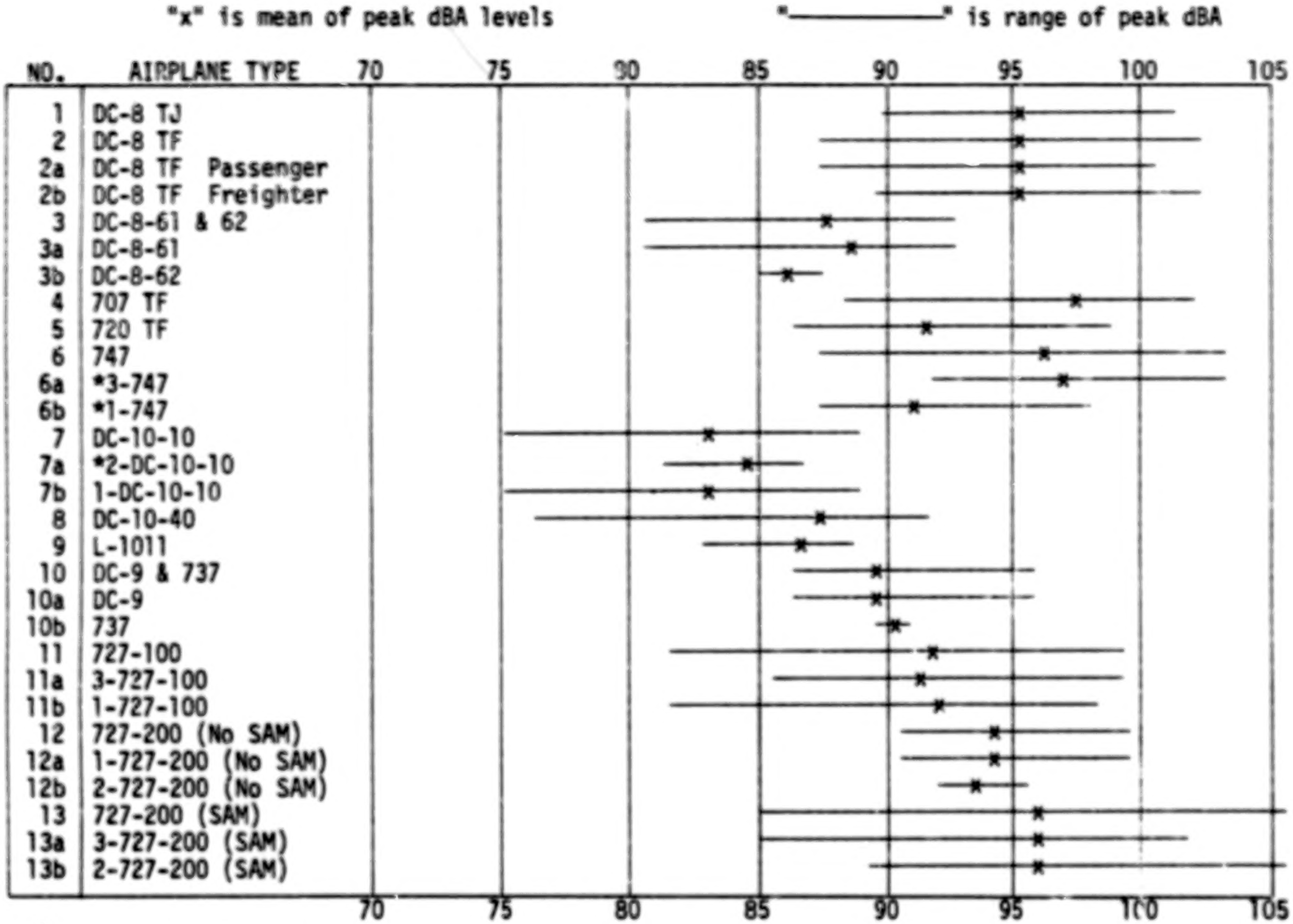
Data analyses were completed using a real-time analyzer in conjunction with a computer.

3.0 RESULTS

Five sections are utilized to present the results. For the most part, noise data are provided in peak dBA levels. The various sections proceed from general descriptions of the noise environments through possible explanations of noise differences between airplane types to the extent that actual measurements agree with measurements based on published noise-thrust-distance data.

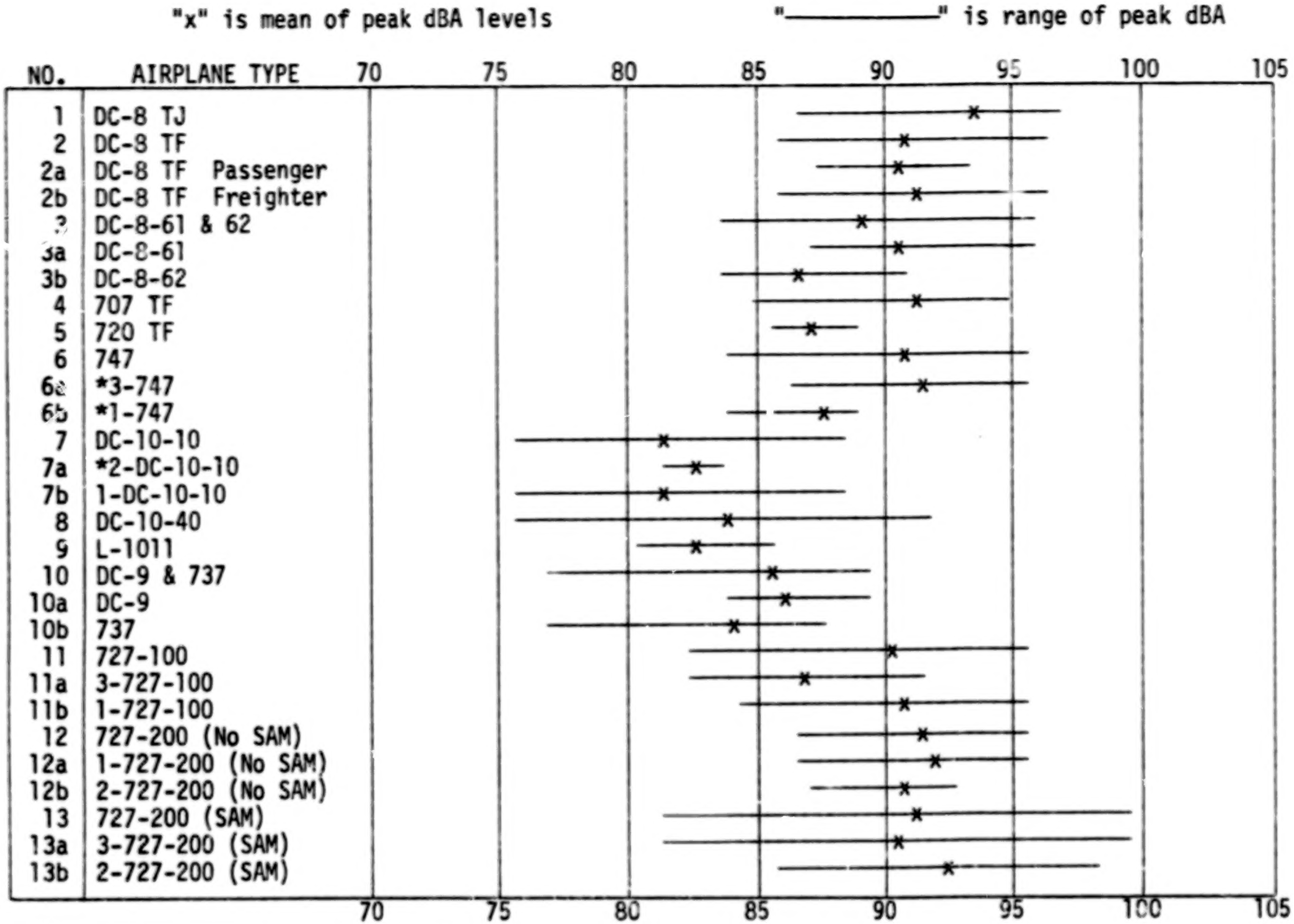
3.1 PEAK dBA NOISE ENVIRONMENTS

The mean peak dBA levels and range of peak dBA levels for various airplane types are given in figures 3-1 through 3-4. Since the emphasis was on obtaining recordings of takeoff operations, more airplane types are identified for takeoffs than for landings. Examination of figures 3-1 through 3-4 leads to the conclusion that persons residing at points comparable to the three recording sites can experience a wide range of peak levels. Table 3-I summarizes the range of peak levels for the recording sites for both takeoffs and landings. At the 3-C recording site (5.63 Km or 3.04 n. mi from brake release), persons could experience outdoor peak levels ranging from 75 to 105 dBA for a total range of 30 dBA; this range of peak levels is completely due to airplane takeoffs as all of the landing peaks are greater than the takeoff minimum of 75 dBA and less than the maximum peak of 105 dBA. For the 3-S recording site (0.68 Km or 0.37 n. mi from centerline), there is a 33 dBA range of peak levels with the lowest peak level of 67 dBA provided by a 2-engine airplane landing. The 5-C recording site (9.64 Km or 5.21 n. mi from brake release) provides



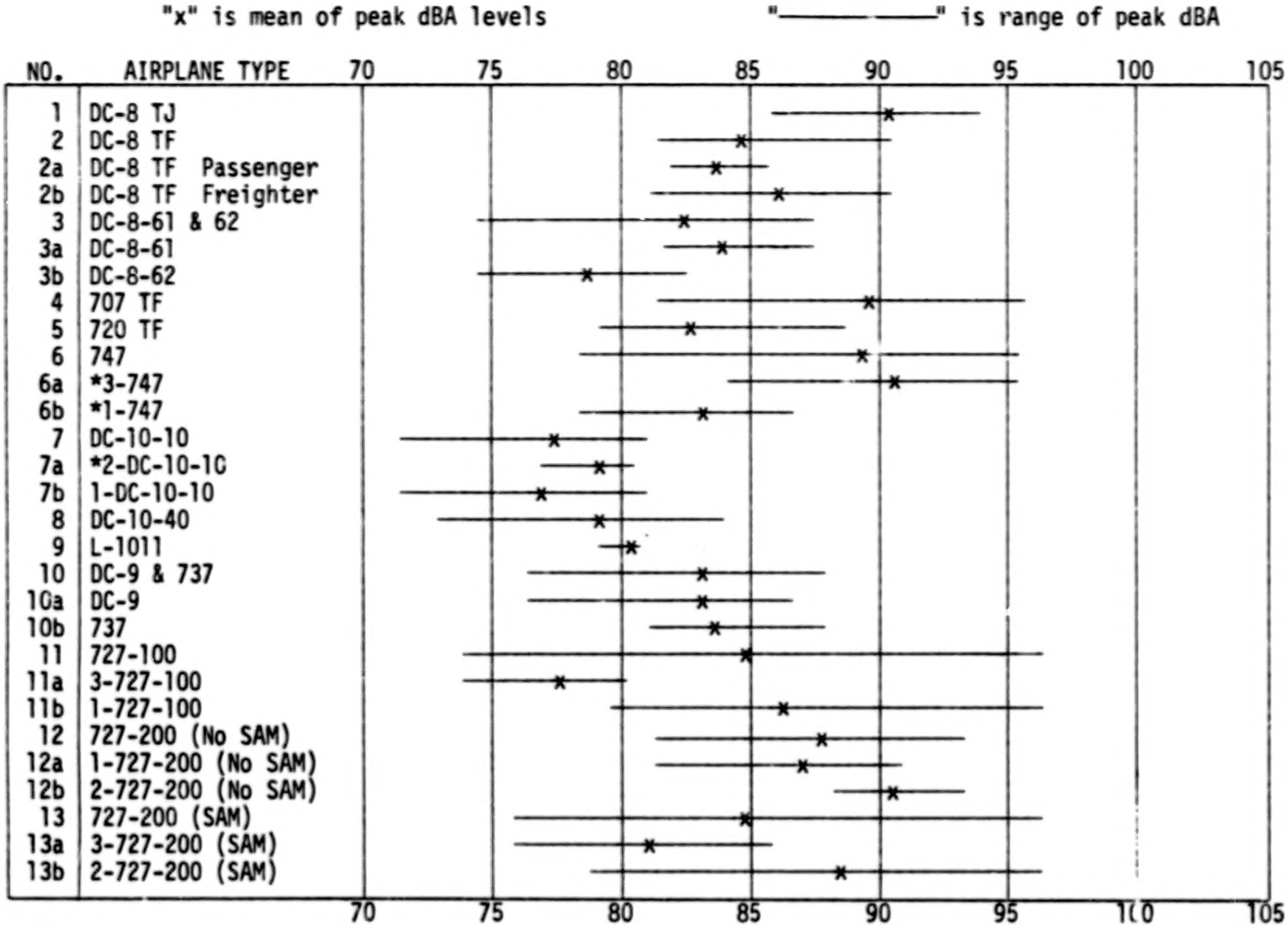
*1,2,& 3 refer to different airlines.

Figure 3-1. Takeoff mean peak dBA Levels ("x") and range of peak dBA levels at recording site 3-C, 5.63 Km (3.04 n. miles) from brake release.



*1,2,& 3 refer to different airlines.

Figure 3-2. Takeoff mean peak dBA levels ("x") and range of peak dBA levels at recording site 3-S, 0.68 Km (0.37 n. miles) from centerline.



*1,2,& 3 refer to different airlines.

Figure 3-3. Takeoff mean peak dBA levels ("x") and range of peak dBA levels at recording site 5-C, 9.64 km (5.21 n. miles) from brake release.

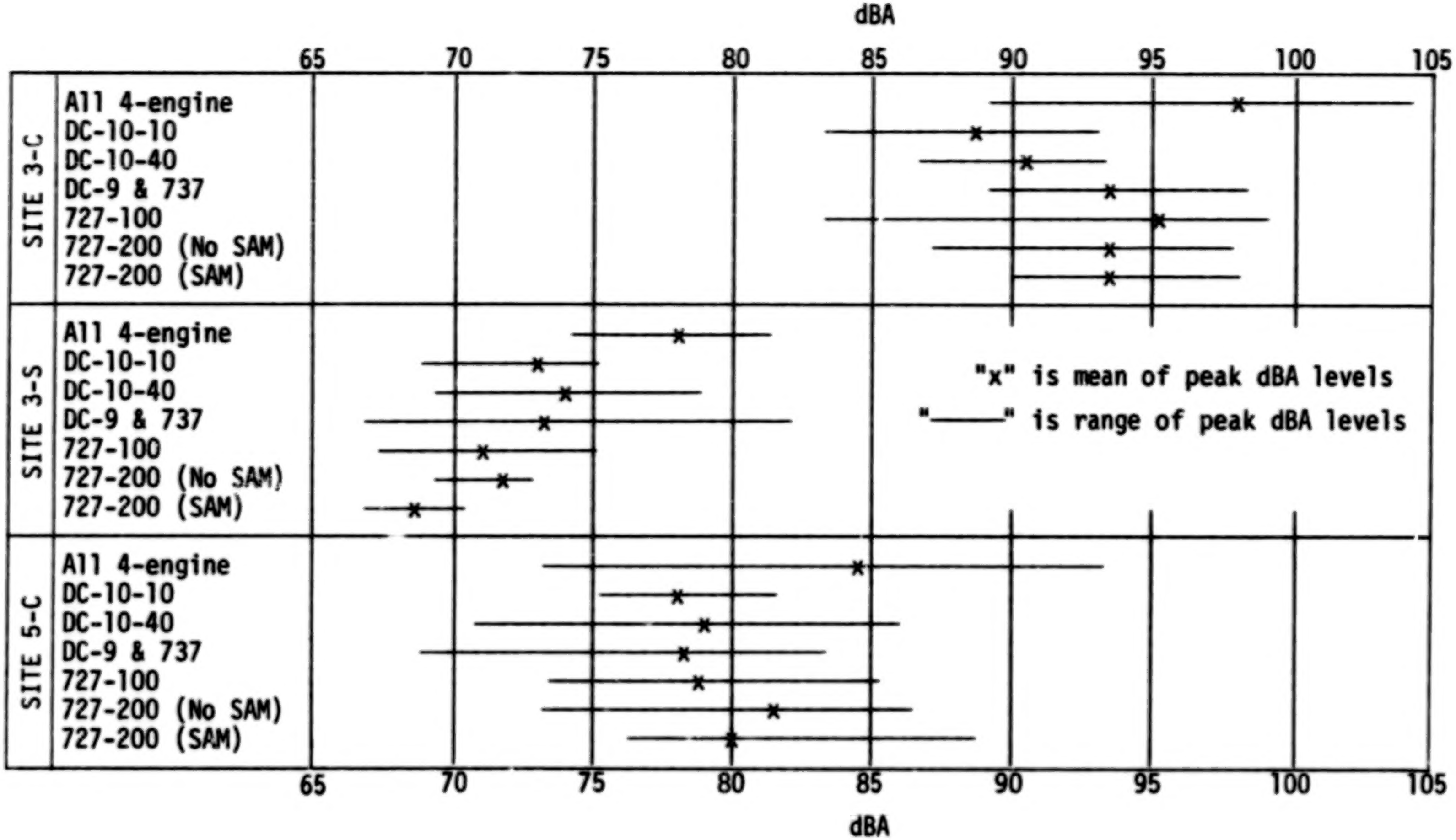


Figure 3-4. Landing mean peak dBA levels ("x") and range of peak dBA levels for the three recording sites.

peak levels ranging from 69 to 96 dBA for a range of 27 dBA. The lowest peak level is from a landing operation while the highest is provided by a takeoff. Since the 5-C recording site is the greatest distance from brake release, it is in an area where airplanes are utilizing a number of flight paths and thus are at differing slant ranges from the recording site. Since differing slant ranges could result in difference noise levels, it is surprising that the smallest range of peak levels was obtained at the 5-C site.

Table 3-I. Range of Peak dBA Levels at the three recording sites.

SITE	TAKEOFFS	RANGE	LANDINGS	RANGE	TOTAL RANGE
3-C	75 to 105	30 dBA	84 to 99	15 dBA	30 dBA
3-S	76 to 100	24 dBA	67 to 92	25 dBA	33 dBA
5-C	72 to 96	24 dBA	69 to 93	24 dBA	27 dBA

3.2 COMPARISONS AMONG AIRPLANE TYPES OR GROUPINGS

For purposes of comparison, airplane takeoff and landing results are grouped according to airplane types and other groupings that could provide meaningful differences. For example, 4-engine turbojet powered airplanes are separated from 4-engine turbofans; 727-200 airplanes with sound absorption material (SAM) treatment are separated from 727-200 airplanes with no sound absorption material (SAM) treatment; for some airplane types, different airlines are flying the same equipment so groupings were also made by airline. Tables 3-II through 3-VII provide results for takeoffs at the three recording sites while Table 3-VIII gives information for land-

ings at all sites. Since the study did not emphasize landings, less data are available for that operation. Utilizing Table 3-II as an example, each airplane grouping is assigned a "No." and if a group is broken down further, letters are attached to that same number to indicate subgroups. For No. 2, DC-8 TF, results based on 11 airplane takeoffs were grouped by whether or not they were operating as passenger or freighter airplanes as a means of determining if there were a noise difference based on that distinction. The peak dBA mean for this subgrouping at the 3-C recording site is 95.2 for both No.'s 2-a and 2-b so it is concluded that there is no noise difference based on a DC-8 turbofan passenger vs. freighter comparison. The Tables 3-II through 3-VII continue with a brief description of a particular grouping (Airplane Descrip.); the number of observations on which the results are based (N); the Mean, Standard Deviation (S.D.), and Range for Peak dBA; the Mean, Standard Deviation (S.D.), and Range for EPNdB; followed by Slant Range and Gross Weight information. Tables 3-II, 3-IV, and 3-VI provide Slant Range and Gross Weight in feet and pounds while Tables 3-III, 3-V, and 3-VII utilize meters (m.) and kilograms (kgm) for Slant Range and Gross Weight. Noise data in Table 3-III are identical to that of Table 3-IV, and 3-VI to 3-VII.

Tables 3-II through 3-VII provide the details for the general descriptions of takeoff noise as provided in figures 3-1, 3-2, and 3-3. The next step is to utilize these details to determine if there are reliable noise differences between the various groupings. For the 29 airplane groupings and subgroupings, at each of the three recording positions there are 406 pairs of means that could be compared to determine if

differences between mean noise levels for the various airplane groupings are reliably different. As a basis for selecting the pairs, the following guidelines were established.

1. Utilize comparisons between pairs of airplane groupings at recording site 3-C as a basis for determining if mean noise measurement differences are reliably different.

2. Make comparisons between pairs for peak dBA differences.

3. Test for a reliable difference if the difference between a pair of means is equal-to-or-greater than 2 dBA.

4. Utilize small sample theory if degrees of freedom are equal-to-or-less than 30 and large sample theory if degrees of freedom are greater than 30.

5. Difference between mean peak dBA levels at the $P \leq .001$ level to be considered reliably different.

As will be observed, as the various pairs of mean differences for peak dBA are investigated, emphasizing the 3-C recording position can lead to omission of significant comparisons at the other two recording sites. These important comparisons that are omitted, due to guideline 3 which establishes a 2 dBA or greater difference between means, will be considered in a later section of the report.

Table 3-IX provides results in accordance with the guidelines given above. The first column of Table 3-IX numbers the 86 pairs of differences between peak mean dBA levels. The second column designates the two airplane categories which are being compared utilizing the number designations of column 1 from Tables 3-II through 3-VII. The third column gives a description of the airplane categories under comparison; for example, comparison No. 1 is between DC-8 TJ (turbojet engines) vs. DC-8-61 & 62 airplanes which have turbofan engines. For the 3-C recording site,

the mean noise difference is 7.5 dBA as shown in the fourth column. Utilizing small sample theory, this difference of 7.5 dBA is significant at $P < .001$ level of confidence which is designated by a "yes" in column 5; testing for a reliable difference between mean dBA levels utilizing Standard Error of Difference between Two Means (SE_{DM}) is:

$$SE_{DM} = \left[\frac{SD^2_{M1}}{N_1} + \frac{SD^2_{M2}}{N_2}\right]^{1/2},$$

where SD_{M1} and SD_{M2} are Standard Deviations for the two samples under comparison and N_1 and N_2 are the number of measurements on which the respective means are based.

For the No. 1 comparison (DC-8 TJ vs. DC-8-61 & 62 airplanes), SE_{DM} is 1.216 and degrees of freedom (df) are 24 since each mean is based on 13 measurements. For comparison purposes, the mean noise differences based on EPNdB according to FAR-36 are given in column 6. Columns 7 to 9 and 10 to 12 provide dBA difference results, whether or not the difference is significant at the $P < .001$ level, and the EPNdB difference between means for recording sites 3-S and 5-C respectively. For the dBA Diff. and EPNdB Diff. results, a minus sign for a difference shows that the aircraft category listed second has a higher noise level than the category listed first; for example, comparison No. 4 shows a dBA difference of - 2.2 which means that the mean level for 707 TF airplane is 2.2 dBA higher than the DC-8 TJ airplane at the 3-C recording site.

A majority of the comparisons of interest are provided in Table 3-XI. However, some were omitted since differences were large enough to make it clear that a particular airplane category was reliably quieter than an-

other. An example involves comparisons between the 4-engine and 3-engine wide-body airplanes which were not completed. In addition, due to the guideline for making comparisons that the difference at the 3-C recording site was to be 2 dBA or greater, an important comparison at the 5-C site was omitted. This comparison involves noise differences at the 5-C recording site as a result of two different takeoff procedures. Figure 3-5 provides flight profiles and descriptions of these two takeoff procedures while Table 3-X gives the noise, slant range, and gross weight results. Since the interest is in noise differences as a result of different takeoff procedures, only mean peak dBA levels for the two procedures but within a particular airplane category are compared. Results were that the 727-100 airplanes flying Takeoff Procedure B (Deep Thrust) were, on the average, 8.4 dBA quieter than 727-100 airplanes flying Takeoff Procedure A (In Route Climb) and those airplanes flying Takeoff Procedure B were also flying at greater gross weights. The 727-200 (SAM) airplanes using Takeoff Procedure B are flying some 7.6 dBA quieter than those flying Takeoff Procedure A but the Procedure B airplanes are also operating at somewhat lesser gross weights.

Table 3-X. Noise, Slant Range, and Gross Weight Results for Two 727 Airplane Takeoff Procedures (Proc. A = In Route Climb, Proc. B = Deep Thrust Takeoff) at SITE 5-C.

AIRPLANE	TAKEOFF PROC.	PEAK dBA DATA			MEAN S.R.		MEAN GR. WT	
		Mean	S.D.	Range	ft	m	lb	kg
3-727-100	B	77.6	2.3	6.3	2787	849	136,991	62138
1-727-100	A	86.0	3.1	16.4	4059	1237	125,274	56823
3-727-200(SAM)	B	80.9	3.3	10.4	2621	799	147,822	67051
2-727-200(SAM)	A	88.7	3.2	16.8	3505	1068	152,715	69270

Table 3-II Mean, Standard Deviation and Range (dBA & EPNdb) for various airplane groupings for takeoffs at recording site 3-C (Range in ft. and Gross Weight in lbs.)

No.	Airplane Descrip	N	Peak dBA Mean	Peak dBA S.D.	Peak dBA Range	Peak EPNdB Mean	Peak EPNdB S.D.	Peak EPNdB Range	Slant Range(ft) Mean	Slant Range(ft) Range	Gross Weight(lbs) Mean	Gross Weight(lbs) Range
1	DC-8 TJ	13	95.3	3.1	11.3	106.3	2.4	8.0	2279	1027	196,400	40,900
2	DC-8 TF	11	95.2	4.8	14.8	108.6	3.9	10.4	2290	2215	230,750	132,300
2-a	DC-8 TF-Pass.	5	95.2	5.2	13.0	109.4	4.6	10.4	2589	1470	206,540	73,900
2-b	DC-8 TF-Fr't.	6	95.2	5.0	12.8	108.0	3.5	9.5	1917	1406	254,960	119,800
3	DC-8-61 & 62	13	87.8	3.1	12.0	102.4	3.0	11.9	2821	669	206,415	44,000
3-a	DC-8-61	9	88.6	3.4	12.0	103.0	3.3	11.9	2798	432	201,944	35,300
3-b	DC-8-62	4	86.1	1.0	2.3	101.3	1.9	4.4	2875	638	216,475	9,900
4	707 TF	12	97.5	3.8	13.6	110.5	3.1	9.0	1587	1406	261,254	120,286
5	720 TF	6	91.6	4.1	12.3	106.0	3.6	10.1	2257	686	189,471	31,323
6	747	25	96.2	3.9	16.1	108.6	3.6	14.4	1572	2199	589,193	365,115
6-a	*3-747	21	97.2	2.8	11.3	109.7	2.2	9.1	1378	890	604,116	365,115
6-b	*1-747	4	90.8	5.0	11.0	102.6	3.5	7.8	2494	1020	510,850	48,100
7	DC-10-10	23	83.3	2.8	13.7	96.3	2.6	12.8	2028	1279	371,876	64,400
7-a	*2-DC-10-10	4	84.7	2.2	5.1	97.5	1.9	4.2	1733	242	401,400	8,500
7-b	1-DC-10-10	18	83.2	2.7	13.7	96.2	2.7	12.8	2048	875	364,929	61,700
8	DC-10-40	35	87.1	3.1	15.4	98.1	2.7	15.5	1602	879	401,172	124,921
9	L-1011	7	86.8	2.0	5.4	98.6	1.8	5.2	1675	1510	371,963	30,217
10	DC-9 & 737	21	89.7	2.0	9.0	100.7	1.5	7.0	1889	1454	86,973	18,008
10-a	DC-9	18	89.7	2.2	9.0	100.5	1.5	7.0	1839	1454	86,311	18,008
10-b	737	3	90.1	0.5	0.9	101.8	0.3	0.7	2188	280	89,400	1,500
11	727-100	54	92.0	3.6	17.4	104.4	3.0	14.0	2530	2856	126,874	66,800
11-a	3-727-100	7	91.2	5.0	13.8	102.2	4.4	11.4	1926	385	137,833	5,669
11-b	1-727-100	46	92.3	3.4	16.5	104.8	2.7	13.8	2607	2856	124,298	30,000
12	727-200(NS)	23	94.4	1.9	8.8	106.4	1.5	7.6	1944	1160	143,850	22,400
12-a	1-727-200 NS	19	94.6	2.0	8.8	106.4	1.6	7.6	1943	1160	143,489	15,500
12-b	2-727-200 NS	4	93.6	1.4	3.2	106.3	0.8	1.7	1947	923	145,475	18,000
13	727-200 **SAM	37	95.6	4.3	20.1	106.5	4.1	19.8	1809	1771	150,137	79,400
13-a	3-727-200 SAM	19	95.5	4.3	16.9	105.3	4.4	16.7	1668	1133	146,759	43,132
13-b	2-727-200 SAM	18	95.6	4.3	15.5	107.7	3.6	13.5	1941	1655	153,515	79,400

* 1,2, and 3 refer to three different airlines

** Sound absorption treatment

Table 3-III Mean, Standard Deviation and Range (dBA & EPNdB) for various airplane groupings for takeoffs at recording site 3-C (Range in Meters and Gross Weight in Kgm)

			Peak dBA			Peak EPNdB			Slant Range (M.)		Gross Weight (Kgm)	
No.	Airplane Descrip	N	Mean	S.D.	Range	Mean	S.D.	Range	Mean	Range	Mean	Range
1	DC-8 TJ	13	95.3	3.1	11.3	106.3	2.4	8.0	695	313	89,087	18,552
2	DC-8 TF	11	95.2	4.8	14.8	108.6	3.9	10.4	698	675	104,668	60,011
2-a	DC-8 TF-Pass.	5	95.2	5.2	13.0	109.4	4.6	10.4	789	448	93,686	33,521
2-b	DC-8 TF-Fr't.	6	95.2	5.0	12.8	108.0	3.5	9.5	584	428	115,650	54,341
3	DC-8-61 & 62	13	87.8	3.1	12.0	102.4	3.0	11.9	860	204	93,630	19,958
3-a	DC-8-61	9	88.6	3.4	12.0	103.0	3.3	11.9	853	132	91,602	16,012
3-b	DC-8-62	4	86.1	1.0	2.3	101.3	1.9	4.4	876	194	98,193	4,491
4	707 TF	12	97.5	3.8	13.6	110.5	3.1	9.0	484	428	118,505	54,562
5	720 TF	6	91.6	4.1	12.3	106.0	3.6	10.1	688	209	85,944	14,208
6	747	25	96.2	3.9	16.1	108.6	3.6	14.4	479	670	267,258	165,616
6-a	*3-747	21	97.2	2.8	11.3	109.7	2.2	9.1	420	271	274,027	165,616
6-b	*1-747	4	90.8	5.0	11.0	102.6	3.5	7.8	760	311	231,722	21,818
7	DC-10-10	23	83.3	2.8	13.7	96.3	2.6	12.8	618	390	168,683	29,212
7-a	*2-DC-10-10	4	84.7	2.2	5.1	97.5	1.9	4.2	528	74	182,075	3,856
7-b	1-DC-10-10	18	83.2	2.7	13.7	96.2	2.7	12.8	624	267	165,532	27,987
8	DC-10-40	35	87.1	3.1	15.4	98.1	2.7	15.5	488	268	181,972	56,664
9	L-1011	7	86.8	2.0	5.4	98.6	1.8	5.2	510	460	168,722	13,706
10	DC-9 & 737	21	89.7	2.0	9.0	100.7	1.5	7.0	576	443	39,451	8,168
10a	DC-9	18	89.7	2.2	9.0	100.5	1.5	7.0	560	443	39,151	8,168
10b	737	3	90.1	0.5	0.9	101.8	0.3	0.7	667	85	40,552	680
11	727-100	54	92.0	3.6	17.4	104.4	3.0	14.0	771	870	57,550	30,300
11a	3-727-100	7	91.2	5.0	13.8	102.2	4.4	11.4	587	117	62,521	2,571
11b	1-727-100	46	92.3	3.4	16.5	104.8	2.7	13.8	795	870	56,382	13,608
12	727-200 (NS)	23	94.4	1.9	8.8	106.4	1.5	7.6	592	354	65,250	10,161
12a	1-727-200 NS	19	94.6	2.0	8.8	106.4	1.6	7.6	592	354	65,087	7,031
12b	2-727-200 NS	4	93.6	1.4	3.2	106.3	0.8	1.7	593	281	65,987	8,165
13	727-200 **SAM	37	95.6	4.3	20.1	106.5	4.1	19.8	551	540	68,102	36,016
13a	3-727-200 SAM	19	95.5	4.3	16.9	105.3	4.4	16.7	508	345	66,570	19,565
13b	2-727-200 SAM	18	95.6	4.3	15.5	107.7	3.6	13.5	592	504	69,634	36,016

* 1,2, and 3 refer to three different airlines

** Sound absorption treatment

Table 3-IV Mean, Standard Deviation and Range (dBA & EPNdB) for various airplane groupings for takeoffs at recording site 3-S (Slant Range in Ft. and Gross Weight in lbs.)

			Peak dBA			Peak EPNdB			Slant Range (ft)		Gross Weight (lbs)	
No.	Airplane Descrip	N	Mean	S.D.	Range	Mean	S.D.	Range	Mean	Range	Mean	Range
1	DC-8 TJ	10	93.5	3.2	10.2	104.9	2.7	9.2	3056	1570	198,470	36,100
2	DC-8 TF	11	90.5	3.0	10.4	104.3	2.9	9.1	3028	1512	216,340	122,800
2a	DC-8 TF-Pass.	6	90.3	2.4	6.0	104.1	2.5	6.0	3060	1265	205,717	73,900
2b	DC-8 TF-Frt.	5	90.9	3.6	10.4	104.6	3.7	9.1	2966	1450	232,275	110,300
3	DC-8-61 & 62	13	89.3	3.3	12.0	102.6	2.1	7.4	3711	1492	209,631	44,300
3a	DC-8-61	9	90.4	2.9	8.6	103.3	1.8	5.4	3883	1003	207,278	44,300
3b	DC-8-62	4	86.8	3.0	7.1	101.0	1.7	3.8	3424	814	214,925	11,500
4	707 TF	13	91.0	3.5	10.0	103.6	3.0	9.3	2881	1401	250,642	134,700
5	720 TF	5	87.1	1.3	2.8	102.0	1.4	3.7	3260	977	191,775	31,497
6	747	27	90.6	2.8	11.4	103.3	2.5	9.4	2617	2159	580,405	365,115
6a	*3-747	22	91.3	2.5	8.9	103.8	2.3	9.4	2513	1897	593,357	365,115
6b	*1-747	5	87.5	2.0	5.0	100.7	1.3	2.8	3012	1635	523,420	77,100
7	DC-10-10	25	81.7	2.7	12.6	93.8	2.0	8.5	2881	1882	377,081	66,625
7a	*2-DC-10-10	4	82.5	1.1	2.3	94.8	0.6	1.4	2527	879	403,238	5,525
7b	1-DC-10-10	20	81.8	2.9	12.6	93.8	2.0	8.5	2891	1657	371,574	63,300
8	DC-10-40	41	83.6	3.0	16.1	95.0	3.0	16.9	2687	1612	397,130	124,921
9	L-1011	7	82.6	1.8	5.0	94.8	1.6	4.7	2785	526	373,125	44,712
10	DC-9 & 737	17	85.4	2.8	12.6	97.4	1.9	7.8	2821	1262	87,637	17,047
10a	DC-9	12	86.0	2.0	5.9	97.5	1.3	4.4	2849	1262	87,131	17,047
10b	737	5	84.0	4.0	10.5	97.3	3.1	7.8	2744	701	88,650	3,076
11	727-100	63	90.3	2.7	13.1	101.4	2.9	14.8	3017	3024	127,331	58,415
11a	3-727-100	5	86.6	4.6	9.1	95.4	4.1	10.2	2917	1231	136,386	4,739
11b	1-727-100	56	90.6	2.3	11.3	101.8	2.1	9.3	3069	3024	125,370	39,000
12	727-200 (NS)	22	91.6	2.3	8.6	102.1	2.0	7.5	2642	1841	147,132	37,794
12a	1-727-200 (NS)	18	91.8	2.3	8.6	102.3	2.0	7.5	2667	1841	144,447	10,900
12b	2-727-200(NS)	4	90.6	2.5	5.6	101.2	2.1	4.7	2546	437	158,542	37,794
13	727-200 (SAM)**	37	91.3	4.4	18.2	101.5	4.3	18.8	2619	1749	148,822	79,400
13a	3-727-200 SAM	21	90.4	4.9	18.2	99.7	4.6	15.8	2511	1687	147,151	44,522
13b	2-727-200 SAM	16	92.4	3.4	12.2	103.8	2.2	8.2	2740	1542	150,912	79,400

* 1, 2, and 3 refer to three different airlines

** Sound absorption treatment

Table 3-V Mean, Standard Deviation and Range (dBA & EPNdB) for various airplane groupings for takeoffs at recording site 3-S (Slant Range in Meters and Gross Weight in Kgm)

No.	Airplane Descrip	N	Peak dBA Mean	Peak dBA S.D.	Peak dBA Range	Peak EPNdB Mean	Peak EPNdB S.D.	Peak EPNdB Range	Slant Range (M) Mean	Slant Range (M) Range	Gross Weight (Kgm) Mean	Gross Weight (Kgm) Range
1	DC-8 TJ	10	93.5	3.2	10.2	104.9	2.7	9.2	931	478	90,026	16,375
2	DC-8 TF	11	90.5	3.0	10.4	104.3	2.9	9.1	923	461	98,732	55,702
2a	DC-8 TF-Pass.	6	90.3	2.4	6.0	104.1	2.5	6.0	933	386	93,313	33,521
2b	DC-8 TF-frt.	5	90.9	3.8	10.4	104.6	3.7	9.1	904	442	105,360	50,032
3	DC-8-61 & 62	13	89.3	3.3	12.0	102.6	2.1	7.4	1131	455	95,089	20,094
3b	DC-8-62	4	86.8	3.0	7.1	101.0	1.7	3.8	1044	248	94,490	5,216
4	707 TF	13	91.0	3.5	10.0	103.6	3.0	9.3	878	427	113,691	61,100
v5	720 TF	5	87.1	1.3	2.8	102.0	1.4	3.7	994	298	86,989	14,287
6	747	27	90.6	2.8	11.4	103.3	2.5	9.4	798	658	263,271	165,616
6a	*3-747	22	91.3	2.5	8.9	103.8	2.3	9.4	766	578	269,146	165,616
6b	*1-747	5	87.5	2.0	5.0	100.7	1.3	2.8	918	498	237,423	34,973
7	DC-10-10	25	81.7	2.7	12.6	93.8	3.0	8.5	878	574	171,044	30,221
7a	*2-DC-10-10	4	82.5	1.1	2.3	94.8	0.6	1.4	770	268	182,909	2,506
7b	1-DC-10-10	20	81.8	2.9	12.6	93.8	2.0	8.5	881	505	168,546	28,713
8	DC-10-40	41	83.6	3.0	16.1	95.0	3.0	16.9	819	491	180,138	56,664
9	L-1011	7	82.6	1.8	5.0	94.8	1.6	4.7	849	160	169,249	20,281
10	DC-9 & 737	17	85.4	2.8	12.6	97.4	1.9	7.8	860	385	39,752	7,732
10a	DC-9	12	86.0	2.0	5.9	97.5	1.3	4.4	868	385	39,523	7,732
10b	737	5	84.0	4.0	10.5	97.3	3.1	7.8	836	214	40,212	1,395
11	727-100	63	90.3	2.7	13.1	101.4	2.9	14.8	920	922	57,757	26,497
11a	3-727-100	5	86.6	4.6	9.1	95.4	4.1	10.2	889	375	61,865	2,150
11b	1-727-100	56	90.6	2.3	11.3	101.8	2.1	9.3	935	922	56,868	17,690
12	727-200 (NS)	22	91.6	2.3	8.6	102.1	2.0	7.5	805	561	66,739	17,143
12a	1-727-200 (NS)	18	91.8	2.3	8.6	102.3	2.0	7.5	813	561	65,521	4,944
12b	2-727-200 (NS)	4	90.6	2.5	5.6	101.2	2.1	4.7	776	133	71,915	17,143
13	727-200 (SAM)**	37	91.3	4.4	18.2	101.5	4.3	18.8	798	533	67,506	36,016
13a	3-727-200 SAM	21	90.4	4.9	18.2	99.7	4.6	15.8	765	514	66,748	20,195
13b	2-727-200 SAM	16	92.4	3.4	12.2	103.8	2.2	8.2	835	470	68,454	36,016

* 1, 2, and 3 refer to three different airlines
** Sound absorption treatment

Table 3-VI Mean, Standard Deviation and Range (dBA & EPNdB) for various airplane groupings for takeoffs at recording site 5-C (Slant Range in ft. and Gross Weight in lbs.)

No.	Airplane Descrip	N	Peak dBA			Peak EPNdB			Slant Range (ft)		Gross Weight (lbs)	
			Mean	S.D.	Range	Mean	S.D.	Range	Mean	Range	Mean	Range
1	DC-8 TJ	10	90.0	2.3	7.9	99.7	2.8	9.8	3748	877	190,378	56,100
2	DC-8 TF	10	84.8	2.7	8.5	98.1	3.5	10.9	4049	3483	217,063	122,200
2a	DC-8 TF-Pass.	5	83.8	1.4	3.6	95.9	1.9	5.0	4659	1627	189,825	13,700
2b	DC-8 TF-Frt.	5	85.8	3.4	8.5	100.3	3.4	8.8	3438	2191	244,300	119,800
3	DC-8-61 & 62	12	82.2	3.7	12.6	95.7	4.1	14.4	4582	4290	206,975	65,900
3a	DC-8-61	8	83.9	1.9	5.3	97.5	1.8	6.6	4142	882	204,425	65,900
3b	DC-8-62	4	78.7	4.3	8.0	92.3	5.6	11.6	5252	4290	212,075	19,000
4	707 TF	12	89.7	4.2	14.3	102.4	3.9	13.4	2367	1953	259,358	146,486
5	720 TF	9	82.6	2.7	9.3	96.8	3.5	10.7	3574	2337	198,628	103,000
6	747	28	89.4	4.2	16.5	101.7	4.2	16.5	2403	2886	587,930	365,115
6a	*3-747	24	90.4	3.4	11.3	102.7	3.4	10.4	2202	1423	596,648	365,115
6b	*1-747	4	83.3	3.6	7.7	95.8	4.2	7.8	3876	1255	535,625	77,100
7	DC-10-10	28	77.3	2.3	8.9	89.7	2.2	8.6	3653	2873	372,970	70,600
7a	*2-DC-10-10	5	79.0	1.6	3.3	91.9	1.3	3.2	3260	1084	401.785	8,500
7b	1-DC-10-10	22	76.9	2.3	8.9	89.2	2.1	8.4	3768	2671	366,110	65,800
8	DC-10-40	38	79.1	2.8	11.1	90.7	2.3	8.9	2516	1586	398,751	122,207
9	L-1011	7	80.4	0.4	1.0	92.4	0.8	2.4	3069	542	374,904	32,257
10	DC-9 & 737	29	82.8	2.1	11.4	94.5	1.9	9.3	3666	2665	86,113	18,951
10a	DC-9	23	82.7	2.0	10.0	94.4	1.9	8.5	3724	2389	83,044	18,951
10b	737	6	83.2	2.6	6.9	94.6	2.0	5.1	3434	1691	88,787	3,076
11	727-100	52	84.9	4.1	22.3	96.9	4.4	25.4	3918	2782	126,915	35,000
11a	3-727-100	7	77.6	2.3	6.3	89.5	3.0	8.6	2787	1088	136,991	5,046
11b	1-727-100	45	86.0	3.1	16.4	98.0	3.3	18.9	4059	1946	125,274	35,000
12	727-200 (NS)	25	88.2	2.5	11.6	100.1	2.5	13.8	3360	1875	145,787	40,821
12a	1-727-200 (NS)	20	87.6	2.4	9.2	99.7	2.4	11.0	3387	1869	143,940	15,500
12b	2-727-200 (NS)	5	90.4	1.8	4.6	101.7	2.5	6.2	3249	781	153,173	37,794
13	727-200 **SAM	44	84.7	5.1	19.9	96.0	5.7	21.5	3074	2605	150,269	79,400
13a	3-727-200 SAM	23	80.9	3.3	10.4	91.5	3.1	10.7	2621	2162	147,822	44,522
13b	2-727-200 SAM	21	88.7	3.2	16.8	101.0	3.0	15.6	3505	1689	152,715	79,400

* 1, 2, and 3 refer to three different airlines

** Sound absorption treatment

Table 3-VII Mean, Standard Deviation and Range (dBA &EPNdB) for various airplane groupings for takeoffs at recording site 5-C (Slant Range in Meters and Gross Weight in Kgm)

No.	Airplane Descrip	N	Peak dBA Mean	Peak dBA S.D.	Peak dBA Range	Peak EPNdB Mean	Peak EPNdB S.D.	Peak EPNdB Range	Slant Range (M) Mean	Slant Range (M) Range	Gross Weight (Kgm) Mean	Gross Weight (Kgm) Range
1	DC-8 TJ	10	90.0	2.3	7.9	99.7	2.8	9.8	1142	267	86,355	25,447
2	DC-8 TF	10	84.8	2.7	8.5	98.1	3.5	10.9	1234	1062	98,460	55,430
2a	DC-8 TF-Pass.	5	83.8	1.4	3.6	95.9	1.9	5.0	1420	496	86,105	6,214
2b	DC-8 TF-Frt.	5	85.8	3.4	8.5	100.3	3.4	8.8	1048	668	110,814	54,341
3	DC-8-61 & 62	12	82.2	3.y	12.6	95.7	4.1	14.4	1397	1308	93,884	29,892
3a	DC-8-61	8	83.9	1.9	5.3	97.5	1.8	6.6	1262	269	92,727	29,892
3b	DC-8-62	4	78.7	4.3	8.0	92.3	5.6	11.6	1601	1308	96,197	86,184
4	707 TF	12	89.7	4.2	14.3	102.4	3.9	13.4	721	595	117,645	66,446
5	720 TF	9	82.6	2.7	9.3	96.8	3.5	10.7	1089	712	90,098	46,721
6	747	28	89.4	4.2	16.5	101.7	4.2	16.5	732	880	266,685	165,616
6a	*3-747	24	90.4	3.4	11.3	102.7	3.4	10.4	671	434	270,639	165,616
6b	*1-747	4	83.3	3.6	7.7	95.8	4.2	7.8	1181	382	242,959	34,973
7	DC-10-10	28	77.3	2.3	8.9	89.7	2.2	8.6	113	876	169,179	32,024
7a	*2-DC-10-10	5	79.0	1.6	3.3	91.9	1.3	3.2	994	330	182,250	3,855
7b	1-DC-10-10	22	76.9	2.3	8.9	89.2	2.1	8.4	1148	814	166,067	29,847
8	DC-10-40	38	79.1	2.8	11.1	90.7	2.3	8.9	767	483	180,873	55,433
9	L-1011	7	80.4	0.4	1.0	92.4	0.8	2.4	935	165	170,056	14,632
10	DC-9 & 737	29	82.8	2.1	11.4	94.5	1.9	9.3	1117	812	39,061	8,596
10a	DC-9-	23	82.7	2.0	10.0	94.4	1.9	8.5	1135	728	38,576	8,596
10b	737	6	83.2	2.6	6.9	94.6	2.0	5.1	1047	515	40,273	1,395
11	727-100	52	84.9	4.1	22.3	96.9	4.4	25.4	1194	848	57,567	15,876
11a	3-727-100	7	77.6	2.3	6.3	89.5	3.0	8.6	849	332	62,139	2,289
11b	1-727-100	45	86.0	3.1	16.4	98.0	3.3	18.9	1237	593	56,824	1,395
12	727-200 (NS)	25	88.2	2.5	11.6	100.1	2.5	13.8	1024	571	66,129	18,516
12a	1-727=200 (NS)	20	87.6	2.4	9.2	99.7	2.4	11.0	1032	570	65,291	7,030
12b	2-727-200 (NS)	5	90.4	1.8	4.6	101.7	2.5	6.2	990	238	69,479	17,143
13	727-200 **SAM	44	84.7	5.1	19.9	96.0	5.7	21.5	937	794	68,162	36,016
13a	3-727-200 SAM	23	80.9	3.3	10.4	91.5	3.1	10.7	799	659	67,052	20,195
13b	2-727-200 SAM	21	88.7	3.2	16.8	101.0	3.0	15.6	1068	515	69,271	36,016

* 1, 2, and 3 refer to three different airlines

** Sound absorption treatment

Table 3-VIII Landing noise and slant range data for three recording sites: 3-C, 3-S, & 5-C.

Site	Airplane Category	N	Peak dBA		EPNdB		Slant Range Feet		Slant Range Meters	
			Mean	Range	Mean	Range	Mean	Range	Mean	Range
3-C	4-Engine	11	98.0	14.6	110.0	14.2	500	189	152	58
	DC-10-10	6	88.9	9.5	100.0	6.7	561	157	171	48
	DC-10-40	5	90.2	6.8	101.0	5.7	510	43	156	13
	DC-9 and 737	7	93.9	9.2	104.4	6.9	524	467	160	142
	727-100	6	95.4	15.4	104.5	10.6	478	69	146	21
	727-200 (No SAM)	8	93.8	10.2	103.3	6.8	539	502	164	153
	727-200 (SAM)	4	93.9	7.9	103.8	5.8	513	38	156	12
3-S	4-Engine	11	77.9	6.9	91.1	6.2	2408	515	734	157
	DC-10-10	4	72.7	6.4	83.0	5.9	2389	70	728	21
	DC-10-40	4	73.8	9.9	82.7	7.5	2308	324	703	99
	DC-9 and 737	6	73.1	15.4	82.3	16.3	2217	857	676	261
	727-100	11	70.9	7.3	81.9	7.8	2330	543	710	166
	727-200 (No SAM)	6	71.6	3.5	82.6	1.6	2360	156	719	48
	727-200 (SAM)	2	68.7	3.0	80.9	2.8	2316	31	706	9
5-C	4-Engine	20	84.5	19.7	97.6	20.3	1426	1112	435	339
	DC-10-10	7	78.3	6.4	90.9	8.3	1893	2136	577	651
	DC-10-40	7	79.4	15.0	91.6	12.7	1558	815	475	248
	DC-9 and 737	14	78.2	14.4	91.0	13.0	1553	1255	473	373
	727-100	17	79.3	10.9	91.4	11.8	1613	964	492	294
	727-200 (No SAM)	14	81.6	13.1	93.3	14.5	1389	655	423	200
	727-200 (SAM)	5	80.1	12.5	92.2	14.3	1636	1121	499	342

Table 3-IX. Difference between takeoff means (dBA & EPNdB) for various pairs of aircraft groupings at all three recording sites.

No.	Comparison	Description	Site 3-C dBA Diff.	Site 3-C *Signf.	Site 3-C EPNdB Diff.	Site 3-S dBA Diff.	Site 3-S Signf.	Site 3-S EPNdb Diff	Site 5-C dBA Diff.	Site 5-C Signf.	Site 5-C EPNdb Diff.
1	1.vs.3.	DC-8TJvsDC-8-61 & 62	7.5	yes	3.9	4.2	no	2.3	7.8	yes	4.0
2	1.vs.3a.	" vs DC-8-61	6.7	yes	3.3	3.1	no	1.6	6.1	yes	2.2
3	1.vs.3b	" vs DC-8-62	9.2	yes	5.0	6.7	no	3.9	11.3	yes	7.4
4	1.vs.4.	" s 707 TF	**-2.2	no	-4.2	2.5	no	1.3	0.3	no	-2.7
5	1.vs.5.	" vs 720 TF	3.7	no	0.3	6.4	yes	2.9	7.4	yes	2.9
6	1.vs.6b.	" vs 1-747	4.5	no	3.7	6.0	yes	4.2	6.7	no	3.9
7	1.vs.7.	" vs DC-10-10	12.0	yes	10.0	11.8	yes	11.1	12.7	yes	10.0
8	1.vs.7a.	" vs 2-DC-10-10	10.6	yes	8.8	11.0	yes	10.1	11.0	yes	7.8
9	1.vs.7b.	" vs 1-DC-10-10	12.1	yes	10.1	11.7	yes	11.1	13.1	yes	10.5
10	1.vs.8.	" vs DC-10-40	8.2	yes	8.2	9.9	yes	9.9	10.9	yes	9.0
11	1.vs.9.	" vs L-1011	8.5	yes	7.7	10.9	yes	10.1	9.6	yes	7.3
12	1.vs.10.	" vs DC9 & 737	5.6	yes	5.6	8.[illegible]	yes	7.5	7.2	yes	5.2
13	1.vs.10a.	" vs DC-9	5.6	yes	5.8	7.[illegible]	yes	7.4	7.3	yes	5.3
14	1.vs.10b.	" vs 737	5.2	yes	4.5	9.5	yes	7.6	6.8	yes	3.1
15	1.vs.11.	" vs 727-100	3.3	no	1.9	3.2	no	3.5	5.1	yes	2.8
16	1.vs.11a.	" vs 3-727-100	4.1	no	4.1	6.9	no	9.5	12.4	yes	10.2
17	1.vs.11b.	" vs 1-727-100	3.0	no	1.5	2.9	no	3.8	4.0	yes	1.7
18	2.vs.3.	DC-8TFvsDC-8-61 & 62	7.4	yes	6.2	1.2	no	1.7	2.6	no	2.4
19	2.vs.3a.	" vs DC-8-61	6.6	no	5.6	0.1	no	1.0	0.9	no	2.2
20	2.vs.3b.	" vs DC-8-62	9.1	yes	7.3	3.7	no	3.3	6.1	no	5.8
21	2.vs.4.	" vs. 707 TF	-2.3	no	-1.9	-0.5	no	0.7	-4.9	no	-5.8
22	2.vs.5.	" vs. 720 TF	3.6	no	2.6	3.4	no	2.3	2.2	no	1.3
23	3.vs.4.	DC-8-61&62 vs 707 TF	-9.7	yes	-8.1	-1.7	no	-1.0	-7.5	yes	-6.7
24	3.vs.5.	" vs 720 TF	-3.8	no	-3.6	2.2	no	0.6	-0.4	no	-1.1
25	3.vs.6.	" vs 747	-8.4	yes	-6.4	-1.3	no	-0.7	-7.2	yes	-6.0
26	3.vs.6a.	" vs 3-747	-9.4	yes	-7.3	-2.0	no	-1.2	-8.2	yes	-7.0
27	3.vs.6b.	" vs 1-747	-3.0	no	-0.2	1.8	no	1.9	-1.1	no	-0.1
28	3.vs.7.	" vs. DC-10-10	4.5	yes	6.1	7.6	yes	8.8	4.9	yes	6.0
29	3.vs.7a.	" vs. 2-DC-10-10	3.1	no	4.9	6.8	yes	7.8	3.2	no	3.6
30	3.vs.7b.	" vs.1-DC-10-10	4.6	yes	6.2	7.5	yes	8.8	5.3	yes	6.5

* "yes" means difference is statistically significant at P< .001 level.
** "-" means second member of pair is at a higher noise level than first member of pair.

Table 3-IX (continued)

No.	Comparison	Description	Site 3-C dBA Diff.	Site 3-C *Signf.	Site 3-C EPNdB Diff.	Site 3-S dBA Diff.	Site 3-S Signf.	Site 3-S EPNdb Diff.	Site 5-C dBA Diff.	Site 5-C Signf.	Site 5-C EPNdb Diff.
31	3.vs.10b.	DC-8-61&62 vs. 737	-2.3	no	0.6	5.3	no	5.3	-1.0	no	1.1
32	3.vs.11.	" vs.727-100	-4.2	yes	-2.0	-1.0	no	1.2	-2.7	no	-1.2
33	3.vs.11a.	" vs.3-727-100	-3.4	no	0.2	2.7	no	7.2	4.6	no	6.2
34	3.vs.11b.	" vs.1-727-100	-4.5	yes	-2.4	-1.3	no	0.8	-3.8	no	-2.3
35	3.vs.12.	" vs.727-200 +NS	-6.6	yes	-4.0	-2.3	no	0.5	-6.0	yes	-4.4
36	3.vs.12a.	" vs.1-727-200 NS	-6.8	yes	-4.0	-2.5	no	0.6	-5.4	yes	-2.0
37	3.vs.12b.	" vs. -727-200 NS	-5.8	yes	-3.9	-1.3	no	0.4	-8.2	yes	-6.0
38	3.vs.13.	" vs.727-200 NS	-7.8	yes	-4.1	-2.0	no	1.1	-2.5	no	-0.3
39	3.vs.13a.	" vs.3-727-200 NS	-7.7	yes	-2.9	-1.1	no	2.9	1.3	no	4.2
40	3.vs.13b.	" vs.2-727-200 NS	-7.8	yes	-5.3	-3.1	no	-1.2	-6.5	yes	-5.3
41	3a.vs 3b.	DC-8-61 vs. DC-8-62	2.5	no	1.7	3.6	no	2.3	5.2	no	5.2
42	4.vs.5.	707 TF vs. 720 TF	5.9	no	4.5	3.9	no	1.6	7.1	yes	5.6
43	4.vs.6b.	707 TF vs. 1-747	6.7	no	7.9	3.5	no	2.9	6.4	no	6.6
44	4.vs.10.	" vs.DC-9&737	7.8	yes	9.8	5.6	yes	6.2	6.9	yes	7.9
45	4.vs.10a.	" vs.DC-9	7.8	yes	10.0	5.0	yes	6.1	7.0	yes	8.0
46	4.vs.10b.	" vs. 737	6.4	yes	8.7	7.0	no	6.3	6.5	yes	7.8
47	4.vs.11.	" vs. 727-100	5.5	yes	6.1	0.7	no	2.2	4.8	yes	5.5
48	4.vs.11a.	" vs. 3-727-100	6.3	no	8.3	4.4	no	8.2	12.1	yes	12.9
49	4.vs.11b.	" vs.1-727-100	4.2	yes	5.7	0.4	no	1.8	3.7	no	4.4
50	4.vs.12.	" vs.727-200 NS	3.1	no	4.1	-0.6	no	1.5	1.5	no	2.3
51	4.vs.12a.	" vs 1-727-200 NS	2.9	no	4.1	-0.8	no	1.3	2.1	no	2.7
52	4.vs.12b.	" vs.2-727-200 NS	3.9	no	4.2	0.4	no	2.5	-0.7	no	0.7
53	4.vs.13a.	" vs.3-727-200 NS	2.0	no	5.2	0.6	no	3.9	8.8	yes	10.9
54	5.vs.6.	720 TF vs. 747	-4.6	no	-2.6	-3.5	yes	-1.3	-6.8	yes	-4.9
55		" vs.3-747	-5.6	no	-3.7	-4.2	yes	-1.8	-7.8	yes	-5.9
56	5.vs.7.	" vs.DC-10-10	8.3	yes	9.7	5.4	yes	8.2	5.3	yes	7.1
57	5.vs.7a.	" vs.2-DC-10-10	6.9	no	8.5	4.6	yes	7.2	3.6	no	4.9
58	5.vs.7b.	" vs.1-DC-10-10	8.4	yes	9.8	5.3	yes	8.2	4.7	yes	5.6
59	5.vs.8.	" vs.DC-10-40	4.5	no	7.9	3.5	yes	7.0	3.5	yes	6.1
60	5.vs.9.	" vs. L-1011	4.8	no	7.4	4.5	yes	7.2	2.2	no	4.4

+ No sound absorption treatment

Table 3-IX (continued)

No.	Comparison	Description	Site 3-C dBA Diff.	Site 3-C Signf.	Site 3-C EPNdB Diff.	Site 3-S dBA Diff.	Site 3-S Signf.	Site 3-S EPNdb Diff.	Site 5-C dBA Diff.	Site 5-C Signf.	Site 5-C EPNdb Diff.
61	5.vs.12	720 TF vs 727-200 NS	-2.8	no	-0.4	-4.5	yes	-0.1	-5.6	yes	-3.3
62	5.vs.12a.	" vs1-727-200 NS	-3.0	no	-0.4	-4.7	yes	-0.3	-5.0	yes	-2.9
63	5.vs.12b.	" vs2-727-200 NS	-2.0	no	-0.3	-3.5	no	0.8	-7.8	yes	-4.9
64	5.vs 13.	" vs 727-200 SAM	-4.0	no	-0.5	-4.2	yes	-0.3	-2.1	no	0.8
65	5.vs 13a.	" vs3-727-200 SAM	-3.9	no	0.7	-3.3	no	2.3	1.7	no	5.3
66	5.vs 13b.	" vs2-727-200 SAM	-4.0	no	-1.7	-5.3	yes	-1.8	-6.1	yes	-4.2
67	6.vs 10.	747 vs DC-9 & 737	6.5	yes	7.9	5.2	yes	5.9	6.6	yes	7.2
68	6.vs 10a.	" vs DC-9	6.5	yes	8.1	4.6	yes	5.8	6.7	yes	7.3
69	6.vs 10b.	" vs 737	6.4	yes	6.8	6.6	no	6.0	6.2	yes	7.1
70	6.vs 11.	" vs 727-100	4.2	yes	4.2	0.3	no	1.9	4.5	yes	4.8
71	6.vs.11a	" vs 3-727-100	5.0	no	6.4	4.0	no	7.9	11.8	yes	12.2
72	6.vs.11b.	" vs 1-727-100	3.9	yes	3.8	0.0	no	1.5	3.4	yes	3.7
73	6.vs.12b.	" vs 2-727-200 NS	2.6	no	2.3	0.0	no	2.1	-1.0	no	0.0
74	6a.vs.6b	3-747- vs 1-747	6.4	no	7.1	3.8	no	3.1	7.1	no	6.9
75	7. vs. 8	DC-10-10vsDC-10-40	-3.8	yes	-1.2	-1.9	no	-1.2	-1.8	no	-1.0
76	7.vs.9.	DC-10-10 vs L-1011	-3.5	yes	-2.3	-0.9	no	-1.0	-3.1	yes	-2.7
77	7.vs.10.	" vs DC-9&737	-6.4	yes	-4.4	-3.7	yes	-3.6	-5.5	yes	-4.8
78	8.vs.10.	DC-10-40 vsDC-9&737	-2.6	yes	-2.6	-1.8	no	-2.4	-3.7	yes	-3.8
79	9.vs.10.	L-1011 vs DC-9 &737	-2.9	no	-2.6	-2.8	no	-2.6	-2.4	yes	-2.1
80	9.vs.10a	L-1011 vs DC-9	-2.9	no	-1.9	-3.4	no	-2.7	-2.3	yes	-2.0
81	9.vs.10b	L-1011 vs 737	-3.3	no	-1.1	-1.4	no	-2.5	-2.8	no	-2.2
82	10.vs.11	DC-9&737 vs 727-100	-2.3	yes	-3.7	-4.9	yes	-4.0	-2.1	no	-2.4
83	10.vs.12.	" vs 727-200NS	-4.7	yes	-5.7	-6.2	yes	-4.7	-5.4	yes	-5.6
84	10.vs.12b.	" vs2-727-200 NS	-3.9	yes	-5.6	-5.2	no	-3.8	-7.6	yes	-7.2
85	11.vs.13.	727-100vs 727-200 NS	-2.4	no	-2.1	-1.0	no	-0.1	0.2	no	0.9
86	12b.vs13b	2-727-200 NS vs 2-727-200 SAM	-2.0	no	-1.4	-1.8	no	-2.6	1.7	no	0.7

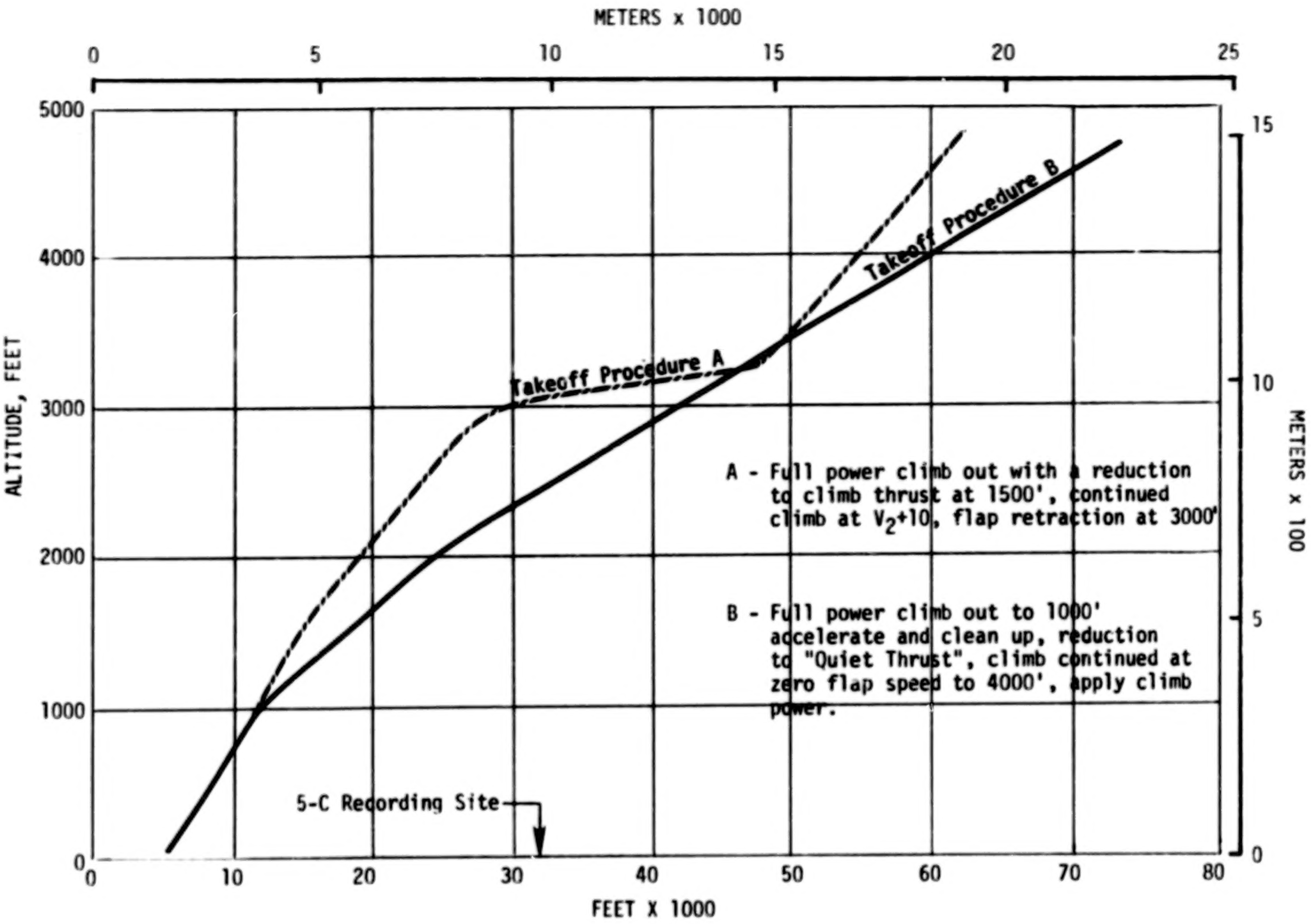


Figure 3-5. Two takeoff procedures for 727 airplanes

3.3 AIRPLANE NOISE PREDICTION

As shown in Table 3-I of Section 3.1, the range of peak dBA levels for takeoffs or landings at a particular point can range from 15 to 30 dBA. In addition to these large ranges of peak levels that lead to difficulty in making accurate assessments of airport noise and its effect on the community, there is the additional finding that comparable operations of airplanes can provide different measurement results on a day-to-day basis. For example, two sets of comparable takeoff measurements at the same point can result in a mean peak dBA difference of 3.5 dBA. For decisions in a critical area involving community effects criteria, this difference can be telling. A different decision would be made on the basis of the lower set of measurements as opposed to the higher set. For these reasons and also economics, much reliance has been placed on noise prediction methods utilizing noise-thrust-distance data based on standardized noise measurement programs. The aim of this section is to compare the measured results at the three recording sites to predicted results for the thirteen main categories of airplanes. The main question involves the agreement between measured and predicted results but at a particular airport.

Mean peak dBA levels for predicted and measured takeoff levels are provided in Table 3-XI. The predicted means are based on predictions by expected gross weights utilizing the data of References 1 to 7, while measured results are those obtained. For the 3-C recording site differences range from + 14.0 dBA to - 7 dBA. Prediction for the DC-8 TJ is 14.0 dBA too high at 3-C while the prediction is 7.0 dBA too low for the 747 airplane. The mean of the differences is approximately 2 dBA; the predicted mean is 2 dBA less than the measured mean. For the sideline measurements at

the 3-S recording site, the predictions are, with the exception of the DC-8 TJ, DC-10-40 and L-1011, too low. The prediction for the DC-9 airplane is 1 dBA lower than measured while the prediction is over 9 dBA lower than measured for the 707-TF. The average of the differences is 3.5 dBA; mean predicted results are 3.5 dBA lower than measured. At the 5-C recording site, differences between predicted and measured results range from approximately plus 5 dBA for the DC-8 TJ airplane (predicted is 5 dBA higher than measured) to minus 8.5 dBA for the 747 airplane (predicted is 8.5 dBA lower than measured). The mean difference is slightly greater than 1 dBA with the mean for predictions lower than measured. On the average, predictions are less than measured by approximately 2.0 dBA at 3-C, 3.5 dBA at 3-S, and 1.0 dBA at the 5-C recording site.

A comparison of predicted vs. measured results for landing operations is given in Table 3-XII. Due to the lesser number of landing measurements as compared to takeoff measurements, airplane groupings are reduced from thirteen to seven. All 4-engine airplanes are grouped together for the landing comparisons as are the DC-9 and 737 airplanes. At the 3-C recording site all mean predictions for landings are greater than the measured mean peak dBA levels, ranging from an over-prediction of 6.0 dBA for the 727-200 (No SAM) airplane to an over-prediction of 1.8 dBA for the 727-200 (SAM) airplane. The average of too high predictions for landings at 3-C is some 4.0 dBA. Results at the 3-S or sideline measurement site are in the opposite direction of those for the 3-C site. With the exception of the 727-200 (SAM) airplane, all mean predictions are lower than those based on measured results, ranging from an insignificant difference of - 0.1 dBA for 727-100 airplanes to - 5.0 dBA for all 4-engine airplanes. The average

Table 3-XI. Noise level comparisons between predicted and measured results (mean peak dBA) for individual airplane takeoffs.

AIRPLANE CATEGORY	3-C SITE			3-S SITE			5-C SITE		
	Predic.	Meas.	Diff.	Predic.	Meas.	Diff.	Predic.	Meas.	Diff.
DC-8 TJ	109.3	95.3	14.0	96.3	93.5	2.8	95.1	90.0	5.1
DC-8 TF	89.8	95.2	- 5.4	85.6	90.5	-4.9	85.7	84.8	0.9
707 TF	87.2	97.5	-10.3	81.7	91.0	-9.3	79.9	89.7	-9.8
720 TF	85.4	91.6	- 6.2	80.4	87.1	-6.7	78.9	82.6	-3.7
747	89.2	96.2	- 7.0	82.9	90.6	-7.7	80.9	89.4	-8.5
DC-10-10	85.9	83.3	2.6	78.8	81.7	-2.9	78.0	77.3	0.7
DC-10-40	89.8	87.1	2.7	84.3	83.6	0.7	83.6	79.1	4.5
L-1011	89.8	86.8	3.0	84.3	82.6	1.7	83.6	80.4	3.2
DC-9	88.6	89.7	- 1.1	85.0	86.0	-1.0	83.6	82.7	0.9
737	84.5	90.1	- 5.6	81.5	84.0	-2.5	80.1	83.2	-3.1
727-100	88.5	92.0	- 3.5	84.4	90.3	-5.9	83.4	84.9	-1.5
727-200 (No SAM)	92.7	94.4	- 1.7	86.8	91.6	-4.8	84.7	88.2	-3.5
727-200 (SAM)	88.7	95.6	- 6.9	86.4	91.3	-4.9	83.2	84.7	-1.5
Mean	90.0	91.9	-1.95	84.5	88.0	-3.49	83.1	84.4	-1.25

Table 3-XII. Noise level comparisons between predicted and measured results (mean peak dBA) for individual airplane landings.

AIRPLANE CATEGORY	3-C SITE			3-S SITE			5-C SITE		
	Predic.	Meas.	Diff.	Predic.	Meas.	Diff.	Predic.	Meas.	Diff.
All 4-engine	103.1	98.0	5.1	72.9	77.9	-5.0	91.8	84.5	7.3
DC-10-10	93.9	88.9	5.0	67.8	72.7	-4.9	81.3	78.3	3.3
DC-10-40	93.1	90.2	2.9	69.1	73.8	-4.7	83.2	79.4	3.8
DC-9 and 737	96.4	93.9	2.5	67.4	73.1	-5.7	84.6	78.2	6.4
727-100	99.5	95.4	4.1	70.8	70.9	-0.1	87.2	79.3	77.9
727-200 (No SAM)	99.8	93.8	6.0	71.2	71.6	-0.4	87.6	81.6	6.0
727-200 (SAM)	95.7	93.9	1.8	70.1	68.7	1.4	85.8	80.1	5.7
Mean	97.4	93.4	3.91	69.9	72.7	-2.77	85.9	80.2	5.88

of under-prediction differences at the 3-S site is approximately 3.0 dBA. At the 5-C site which is an under-the-flight-path position, mean predictions again consistently exceed the measured data. Predictions range from 3.3 dBA higher than measured data for the DC-10-10 airplane to 7.9 dBA too high for the 727-100 airplane. In summary, the mean predicted results for approaches are some 4.0 dBA greater than measured results at 3-C, approximately 3 dBA lower at 3-S, and some 6 dBA higher at 5-C than the measured data.

The agreement based on the various airplane categories, between the predicted and measured results as provided above is disappointing. However, another approach for examining differences between predicted and measured results involves combining peak dBA levels in terms of average airport operations for landings and takeoffs. At the Seattle-Tacoma International Airport, areas south of the airport are, on average, exposed to 1/3 approach and 2/3 takeoff operations. The question involves the extent of agreement for mean peak dBA levels when combining approach and takeoff operations based on a weighting utilizing typical airport operating conditions. Table 3-XIII provides the essentials for this comparison. Column 1 identifies the three recording sites while column 2 gives two mean peak dBA levels for the approach predicted results. The upper or first predicted result is based on the unweighted means of various airplane categories (predicted mean from Table 3-XII) while the second predicted result is based on the fleet mix operating during the period that the measurements were obtained. Note that the two approaches for obtaining the predicted means are quite comparable; if approach and takeoff operations are combined in accordance with typical airport operating conditions (column 4), the

Table 3-XIII Comparison of predicted and measured results approach and takeoff results combined based on typical airport operation.

SITE	PREDICTED			MEASURED			Predicted less Meas.
	AP	TO	AP & TO	AP	TO	AP & TO	
3-C	+97.4 *98.0	+90.0 *89.0	+92.5 *91.9	93.4 N = 47	91.9 N = 288	92.4	0.0
3-S	+69.9 *70.0	+84.5 *84.2	+79.6 *79.7	72.7 N = 44	88.0 N = 278	82.9	-3.0
5-C	+85.9 *86.6	+83.1 *82.7	+84.0 *83.9	80.2 N = 84	84.4 N = 293	83.0	+1.0

+ Based on average by airplane.

* Fleet mix predicted.

N is number of observations on which mean is based.

difference between the two methods for obtaining predicted means is 0.6 dBA at 3-C, 0.1 dBA at both 3-S and 5-C. Utilizing the mean peak dBA levels of Column 4 vs the measured mean peak dBA levels of Column 7, there is virtually no difference between predicted and measured means at the 3-C recording site, the measured mean is approximately 3 dBA higher at the 3-S site than the predicted mean, and the predicted mean is 1 dBA higher than the measured mean at the 5-C recording site. Thusly, it can be concluded that, on the average, agreement between predicted and measured results is satisfactory under the flight path, but at sideline, the mean of the predicted results is too low.

As a means of checking the comparisons between the mean predicted results and the mean measured results at the three recording sites, data from ten additional points were examined. The predicted means are based on the average fleet mix during the time frame that the measurements were made while the measured means are based on the peak levels obtained. Peak

levels were available for approximately 1,500 operations, some 500 approaches and over 1,000 takeoffs. Figure 3-6 provides a schematic of the airport and utilizes a coordinate system to locate the 10 additional measurement points plus the 3-C, 3-S, and 5-C recording sites. The south end of runway B is taken as the zero point of the coordinate system. Points 1, 2, 4, 6, 7, and 10 along with 3-S are sideline measurement points while points 3, 5, 8, and 9 along with 3-C and 5-C are categorized as under-the-flight-path measurement points. Based on the location of measurement point 9 relative to runway A (preferential runway for both approaches and takeoffs for noise exposure to the north), it appears that point 9 should be categorized as an under-the-flight-path point. However, due to a noise abatement procedure, traffic tends to bear to the west and in particular for takeoff operations. Table 3-XIV provides comparison information between predicted and measured mean dBA levels for the 10 additional points plus that obtained at the 3 original measurement sites. For takeoffs, measured results are higher than predicted results at all 13 points, ranging from 1 to 4 dBA. However, there is a tendency for greater differences at sideline than under the flight path. The average of the under-predictions at sideline is 2.7 dBA based on 7 points while it is 1.8 dBA for the 6 points under the flight path (see Table 3-XV). At sideline, three of the points show under-predictions of 4 dBA while but one point under the flight path shows an under-prediction as high as 3 dBA. Turning to the approach differences, the predicted means are consistently higher than the measured means for the 6 points under the flight path; the average of the mean of the differences is 3.2 dBA greater for the predicted means as opposed to the measured

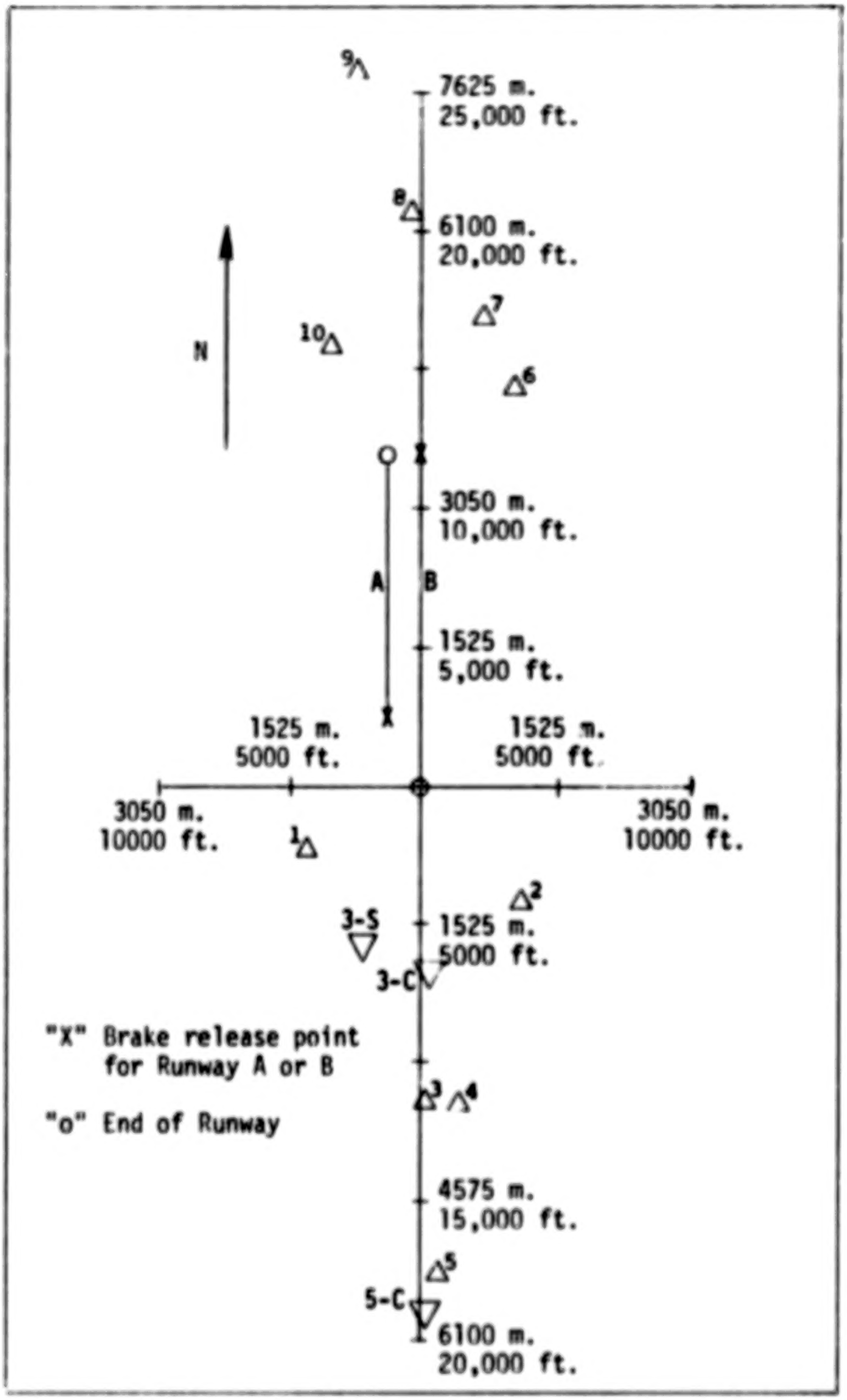


Figure 3-6. Schematic of airport and location of 10 additional measurement points.

Table 3-XIV Mean predicted less mean measured results for ten additional measurement points (mean dBA difference).

POINT	TAKEOFF	APPROACH	LOCATION
1	-4	-16	*S
2	-2	- 5	S
3	-3	+ 2	U
4	-1	- 4	S
5	-2	+ 4	U
6	-2	- 8	S
7	-2	- 6	S
8	-2	0	U
9	-1	+ 3	U
10	-4	-11	S
3-C	-2	+ 4	U
3-S	-4	- 3	S
5-C	-1	+ 6	U

* S is sideline measurement point, U is under flight path.

Table 3-XV Summary data for differences between predicted and measured results - under-flight-path vs sideline (mean dBA differences).

	TAKEOFF		APPROACH	
	Mean	Range	Mean	Range
Under Flight Path	-1.8	-1 to -3	+3.2	0 to + 6
Sideline	-2.7	-1 to -4	-8.8	-3 to -16

means with differences ranging from 0.0 to 6.0 dBA (Table 3-XV).

However, for the sideline comparisons the situation is exactly reversed. Predicted means are consistently lower than the measured means; the average of these lower differences is 8.8 dBA and the under-predictions range from 3 to 16 dBA (Table 3-XV). There is a tendency to under-

predict noise levels at sideline, and for approach operations, under-prediction is unusually high. Although it is clear, from examination of comparisons of predicted vs measured results for the various airplane categories (Tables 3-XI and 3-XII), that the state-of-the-art noise thrust distance data is not always accurate for this particular airport, another more important factor related to these large under-predictions at sideline are the standard corrections (Ref. 8) utilized to account for extra ground attenuation. The results from the above comparisons strongly support a conclusion that, to a large extent, the under-predictions at sideline are due to the extra ground attenuation corrections.

3.4 GROSS WEIGHTS AND SLANT RANGE EFFECTS

At a particular observer point, noise levels are a function of gross weight (power) and slant range (distance from noise source). A question relative to these two measures is the extent that noise levels can be determined as a function of differences in gross weight and slant range. What is the quantitative contribution of the slant range and gross weight variables to noise levels at a commercial airport? Results bearing on this problem were obtained using linear multiple regression methods. For each of the three recording positions, measured noise levels in peak dBA and EPNdB were related to airplane gross weights and slant ranges using an equation of the form:

$$\text{dBA or EPNdB} = aX_1 + bX_2 + cX_3 + d$$

where: X_1 = gross weight in pounds or kilograms
X_2 = slant range in feet or meters
X_3 = log(slant range).

The main aim of this approach was to determine the extent, in dB, that predictive capability was increased by taking into account gross weight and slant range effects. This aim was accomplished by comparing predictive capability <u>without</u> considering gross weight and slant range effects to the multiple regression results which <u>did</u> include these effects. A set of noise measurements for a particular class of airplanes will provide a mean and standard deviation for that set of measurements. The magnitude of the standard deviation is a function of a number of variables which include:

- Measurement Error
- Gross Weight
- Slant Range
- Atmospheric Conditions, etc.

However, if gross weight and slant range are taken into account via the linear multiple regression approach, the standard deviation for the uncorrected or original set of measurements will be reduced as a function of the extent that gross weight and slant range determine noise levels. In fact, if there were no measurement error and noise level at a particular observer point were completely determined by variability in gross weight and slant range, the standard deviation for that set of measurements would be reduced to zero and all measurements in that set would be exactly the same. Thus, the approach is to determine the extent that standard deviations for various sets of noise measurements are reduced due to accounting for gross weight and slant range. The "standard deviation" for a set of measures which are determined via this multiple regression approach is called the standard error of estimate.

Differences between uncorrected standard deviations and those where gross weight and slant range are held constant via linear multiple regression are provided in Table 3-XVI. If there is no or some effect on noise measurements due to gross weight and slant range, and there is no rounding error, the corrected standard deviations (standard error of estimate) will always be equal-to-or-less than the original or uncorrected standard deviation. The results on which the differences of Table 3-XVI are based are given in Appendix A. Using Airplane Category No. 1 as an example, which involves holding gross weight and slant range constant for "All" airplanes, with the exception of the EPNdB calculation procedure measurements at recording site 5-C, the standard deviations are reduced by approximately 0.5 dB or less. This finding is not surprising since the heavier airplanes with high bypass engines make less noise than the lighter narrow-body airplanes with low bypass power plants. Effects on noise levels of taking gross weight and slant range into account cannot be determined by results based on all airplanes. The explanation for the 1.10 EPNdB reduction at the 5-C recording site is, perhaps, due to the fact that the standard deviation for the basic set of measurements was relatively large (see row No. 1 for Tables A-I and A-II). The range of measurements for all airplanes at site 5-C is approximately 26 EPNdB but if gross weight and slant range are taken into account the range is reduced to slightly less than 22 EPNdB. The magnitude of the standard deviation for the basic set of noise measurements will influence the effect of accounting for gross weight and slant range effects.

Before examining effects of gross weight and slant range on noise

Table 3-XVI Standard deviations (S.D.) less standard errors of estimate (S.E.) in peak dBA and EPNdB for twenty-two airplane categories or groupings.

		Peak dBA			EPNdB		
		Measurement Sites			Measurement Sites		
NO.	AIRPLANE CATEGORY	3-C	3-S	5-C	3-C	3-S	5-C
1	All airplanes	0.44	0.53	0.21	0.24	0.24	1.10
2	All 4-eng. Nar. body	1.36	0.98	1.31	1.09	0.75	2.06
3	All 4-eng. Turbofan	1.78	0.95	2.26	1.19	0.70	2.72
4	All 4-eng. Turbojet	0.02	1.73	0.21	0.40	1.03	0.60
5	DC-8 Turbofan	1.08	0.70	1.26	0.68	0.82	2.11
6	707 and 720 Turbofan	2.53	1.38	2.70	1.75	0.84	2.84
7	707 Turbofan	2.36	2.11	1.89	1.55	1.49	2.25
8	720 Turbofan	0.78	-0.04	1.58	0.56	0.64	1.96
9	All Wide Body	2.14	1.74	3.52	2.46	1.89	3.67
10	747	0.69	0.60	2.20	0.90	0.41	2.77
11	DC-10-10	0.42	0.66	1.00	0.05	0.89	1.05
12	DC-10-40	0.00	0.08	0.84	0.00	0.15	0.66
13	L-1011	0.48	0.42	0.00	0.30	0.09	0.06
14	DC-9 and 737	0.19	0.26	0.07	0.15	0.29	0.52
15	All 727	0.80	0.50	0.64	0.53	0.25	0.67
16	All 727-100	0.24	0.17	0.65	0.16	0.24	0.63
17	All 727-200	1.13	0.94	0.79	1.15	0.46	0.99
18	All 727-200 (No SAM)	0.07	0.60	0.24	0.00	0.28	0.30
19	1-727-200 (No SAM)	0.02	0.79	-0.02	0.00	0.26	0.03
20	All 727-200 (With SAM)	1.49	1.14	1.34	1.60	0.59	1.72
21	3-727-200 (With SAM)	1.76	2.30	1.31	2.29	2.10	2.00
22	2-727-200 (With SAM)	2.53	1.13	0.42	1.82	0.50	0.49
	MEAN	1.01	0.89	1.11	0.86	0.68	1.42
	STANDARD DEVIATION	0.86	0.64	0.95	0.77	0.54	1.03
	RANGE	2.53-0.00	2.30--0.04	3.52--0.02	2.46-0.00	2.10-0.09	3.67-0.03

measurements using some of the airplane categories of Table 3-XVI, the summary information as provided in the last three columns of Table 3-XVI is discussed. Mean dBA reduction in the standard deviation (S.D.) ranges from 0.89 to 1.11 dBA depending on the recording site considered. Under

the assumption that four times the S.D. covers the range of almost all measurements, range of measured data is, on the average, reduced by some 3.5 to 4.5 dBA by accounting for gross weight and slant range. For the EPNdB calculation procedure the range of measured data is, on the average, reduced by some 2.7 to 5.7 EPNdB if gross weight and slant range are accounted for. Turning to the range of reductions obtained for specific airplane categories (bottom row of Table 3-XVI), they range from 0.0 dB to 4 x 3.67 = 14.7 dB for the largest reduction at recording site 5-C using EPNdB.

Using peak dBA, reductions in the range of measurements due to holding gross weight and slant range constant are considered for specific airplane categories. For Airplane Category No. 2 which involves results based on all 4-engine narrow-body airplanes, reductions in the standard deviations are 1.78, 0.95, and 2.26 dBA at recording sites 3-C, 3-S, and 5-C respectively. These results indicate a reduction in the range of measurements of approximately 7, 4, and 9 dBA by accounting for gross weight and slant range effects. On a percentage basis, this is a reduction in measurement range of 33, 30, and 49 percent at recording sites 3-C, 3-S, and 5-C respectively. The effect of accounting for gross weight and slant range is more pronounced at 5-C which is at the greatest distance from the airport. The category of 4-engine narrow-body airplanes which shows the highest reduction involves turbofan airplanes identified as No. 6 in Table 3-XVI. Reductions in range of measured dBA peak levels are approximately 10, 5.5, and 11 dBA for 3-C, 3-S, and 5-C respectively. Percent reductions are 52% at site 3-C, 41% at site 3-S, and 55% at site 5-C.

Reductions in range of peak dBA levels for the wide-body jets begin with No. 9 of Table 3-XVI. Using the rule of four times a S.D. to cover a range of measurements, reductions are approximately 7 dBA at the 3-S recording site and 14 dBA at the 5-C site if all wide-body airplanes are investigated as a group (No. 9). Percentage reductions due to accounting for gross weight and slant range are 39% at 3-C, 38% at 3-S, and 60% at the 5-C measurement site. Examination of the differences between the standard deviation (S.D.) and the standard error (S.E.) for specific wide-body jet transports (No's 10 - 13) shows that decrease in the absolute range of measurements is generally not as great as that achieved for all wide-body airplanes considered as a group. For the DC-10-10 (No. 11) there is a 43% reduction at 5-C and for the 747 (No. 10) there is a 52% reduction in range of measurements at site 5-C. Results from the L-1011 airplane (No. 13) are used to illustrate the relationship between the magnitude of the actual measurement range and the absolute reduction that can be achieved by accounting for gross weight and slant range. A summary of the results are provided in Table 3-XVII. As the S.D. column of

Table 3-XVII Reduction in range of L-1011 airplane peak dBA measurements as a result of accounting for gross weight & slant range.

Measure. Site	S.D.	S.E.	dBA Reduction	Reduction in Range of Meas.	% Reduction in Range
3-C	1.40	0.92	0.48	1.92 dBA	34%
3-S	1.77	1.35	0.42	1.68 dBA	24%
5-C	0.37	0.37	0.00	0.00 dBA	00%

Table 3-XVII shows, the range of measured peak dBA levels is relatively

small at all three sites and particularly at the 5-C site where the S.D. is 0.37 dBA. In fact, the measured data at all three sites meets the 90% confidence interval of ±1.5 dB for FAR-36 certification and without corrections for gross weight and slant range. For the two sites with the relatively larger range of peak dBA levels (3-C and 3-S), there is a reduction in range of peak levels of 34% at 3-C and 24% at 3-S by accounting for gross weight and slant range. At 5-C, which has an unusually small S.D. of 0.37 dBA, accounting for gross weight and slant range results in no reduction. This is attributed to the unusually small range exhibited in the uncorrected set of measurements. That the range of measured peak dBA levels is so small at all three sites may be a result of but one airline flying the L-1011 at Sea-Tac International Airport. Perhaps commercial jet airplanes can be flown more consistently from the standpoint of noise exposure.

Results for the 2-engine narrow-body airplanes (No. 14) show that little reduction in range of peak level measurements due to gross weight and slant range is achieved at any of the recording sites. This is in part due to the relatively small range of uncorrected measurements (see Row No. 14 of Table A-1, Appendix A).

The final set of comparisons is concerned with various groupings of the 727 airplane noise measurements. Little reduction is achieved if all 727 airplanes are considered as a category (Row No. 15) and 727-100 measurements (Row No. 16), in isolation from the 727-200 airplane, do not show an appreciable reduction in measurement range if gross weight and slant range are taken into account. Reductions in measurement range

are increased for All 727-200 airplanes (No. 17) over All 727 (No. 15) and All 727-100 (No. 16) categories. However, a comparison among all measurement reductions for 727 airplanes (No's 15 - 22) shows that this reduction in measurement range is primarily due to two airlines flying 727-200 (With SAM) airplanes. Thusly, results for the 727-200 which are sound absorption material (SAM) treated are examined in detail in Table 3-XVIII (No's 20, 21, & 22). Reductions in range of measured data are from 13% to 58%. These low and high reductions due to accounting for gross weight and slant range are both produced by airline "2"; the low of 13% increase is at site 5-C and the high of 58% is at the close-in 3-C recording site. With the one exception for airline "2" at recording site 5-C, reductions in measurement range are increased due to examining results separately for the two airlines.

In respect to the effect of gross weight and slant range on peak dBA noise measurements, some tentative conclusions are:

- Variations in gross weight and slant range are more likely to influence peak dBA noise levels at greater distances from the airport than at close-in observer positions.
- By accounting for effect of gross weight and slant range using specific airplane categories, range of peak dBA measured levels can be reduced 50-60%.
- Noise measurements based on takeoffs of a specific airline and using a particular airplane type tend to show greater precision (smaller range of corrected measurements) than for a mix of airlines flying the same equipment.

The product-moment coefficients of correlation on which the multiple regression equations are based are provided in Appendix B.

Table 3-XVIII Reduction in range of 727-200 (With SAM) peak dBA measurements as a result of accounting for gross weight and slant range - two airlines only.

Site	*Airplane Category	S.D.	S.E.	dBA Reduction	Reduction in Range of Meas.	Percent Reduction in Range
	All 727-200	4.46	2.97	1.49	5.96 dBA	33%
3-C	3-727-200	4.70	2.94	1.76	7.04 "	37%
	2-727-[illegible]	4.38	1.85	2.53	10.12 "	58%
	All 727-200	4.51	3.37	1.14	4.56 dBA	25%
3-S	3-727-200	5.17	2.87	2.30	9.20 "	45%
	2-727-200	3.37	2.24	1.13	4.52 "	34%
	All 727-200	5.04	3.70	1.34	5.36 dBA	27%
5-C	3-727-200	3.32	2.01	1.31	5.24 "	39%
	2-727-200	3.16	2.74	0.42	1.68 "	13%

* Based on measurements of only 727-200 airplanes treated with sound absorption material (SAM).

Although precision for noise measurements can be increased by 50-60% at particular observer points using specific categories of airplanes, in respect to commonly used methods for categorizing airplanes, what is the gain in precision across all airplanes due to accounting for gross weight and slant range? Using six conventional noise modeling classes of airplanes:

4-engine Turbojet (TJ)
4-engine Turbofan (TF)
4-engine High Bypass (747)
3-engine High Bypass (DC-10)
2-engine Fanjet (DC-9)
3-engine Fanjet (727) ,

increases in precision are provided in figure 3-7 for the three recording sites. Beginning with the results for recording site 3-C, reductions in

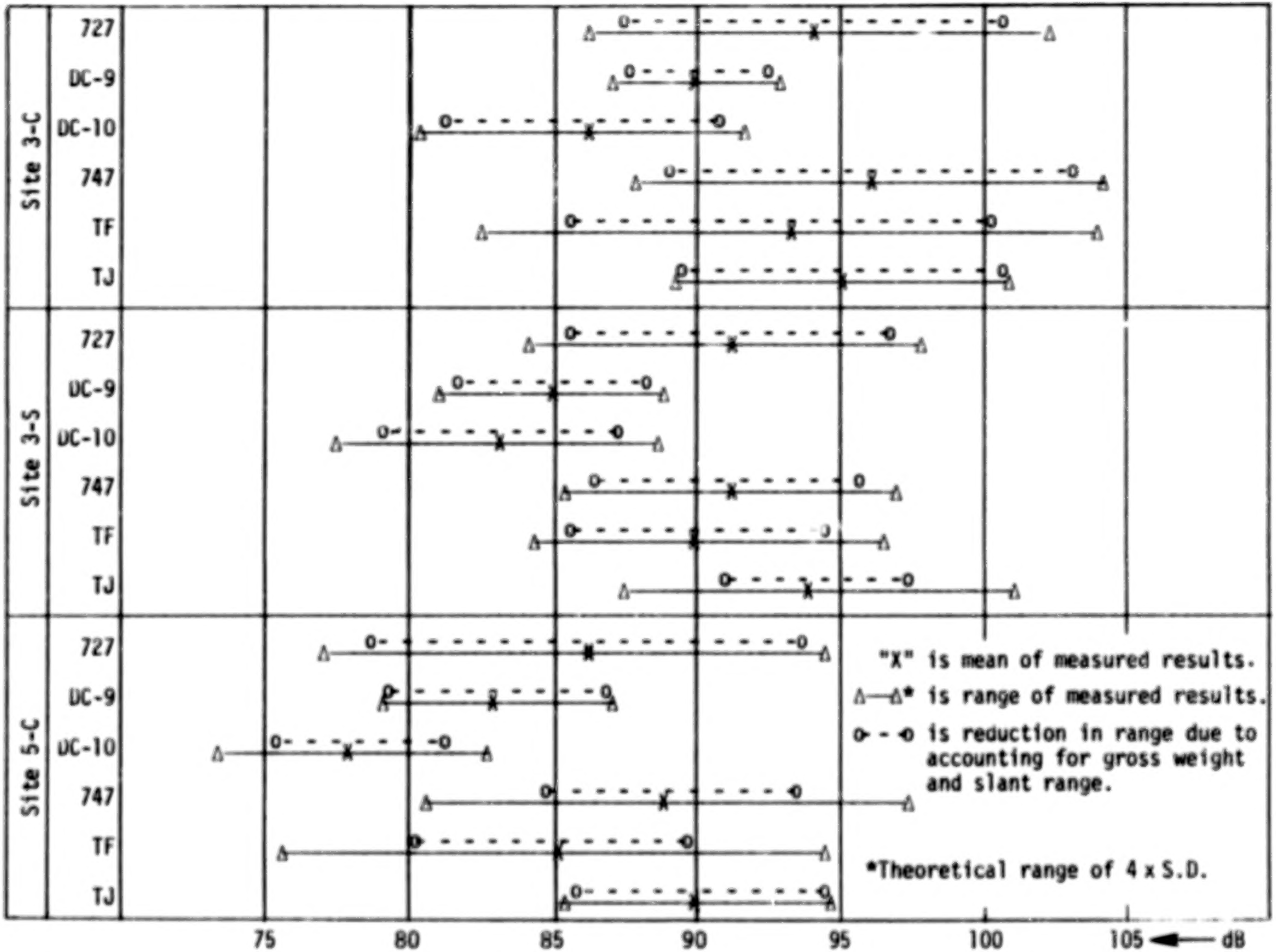


Figure 3-7. Reductions in range of noise measurement due to accounting for gross weight and slant range based on six categories of airplanes commonly used for airport noise modeling.

measurement range are not appreciable with the exception of those based on the "TF" class of airplanes. However, the range for all airplanes at the upper limit is controlled by the 747 airplane and at the lower limit by noise produced by the DC-10 airplane. Thus, the measured range of measurements across all airplanes is reduced by only 2.1 dBA when accounting for gross weight and slant range. This is a 9% increase in precision for all airplanes. For the 3-S or sideline recording site, there is a decrease of 3.2 dBA for the "TJ" class of airplanes at the upper noise level and of 1.4 dBA for DC-10 airplanes at the lower level. This provides a 12% increase in precision across all airplanes due to accounting for gross weight and slant range. Results for the 5-C measurement site are somewhat more encouraging since precision is increased appreciably for both the "TF" and 747 airplanes leading to a 21% increase in precision across all airplanes.

3.5 COMPARISONS BETWEEN PEAK dBA AND EPNdB MEASUREMENTS

The two most widely used noise exposure methods for measuring airport community noise effects in the United States are Day-Night Level (L_{dn}) and Noise Exposure Forecast (NEF). In an applied situation, there is often interest in determining one method from the other. The approximate constant difference between the two is given as:

$$L_{dn} \doteq NEF + 35 \; (\pm 3 \text{ dB}) \qquad \text{(Ref. 9, p. A-20)}$$

Since dBA is the engineering calculation procedure or weighting network basic to L_{dn} and EPNdB is the procedure basic to NEF, a comparison of

measurement results based on the two procedures can provide information relative to the comparability of these two community noise exposure measurement methods. In addition, there is interest in the comparability between EPNdB and peak dBA as a means of measuring response to individual flyover events.

Table 3-XIX provides means for EPNdB and peak dBA, and differences between the means (mean EPNdB less mean peak dBA) for twenty-two airplane categories or groupings (Takeoffs only). For all three measurement positions, peak dBA averages approximately 12 dB less than EPNdB, 12.2 for site 3-C, 11.9 for site 3-S, and 12.1 for measurement site 5-C. However, for the specific airplane categories, the range of the mean differences is approximately 4 to 5 dB, depending on the measurement site being considered. Except for the difference at the 5-C recording site, the smallest difference between mean EPNdB and mean peak dBA is for comparison No. 21 which is based on the 727-200 (with SAM) airplane but flying takeoff Procedure B as shown in figure 3-5. The largest difference between EPNdB and peak dBA is provided by the 720 turbofan airplane which is comparison No. 8. Figure 3-8 depicts these ranges of differences using five of the airplane categories. Except for the 4-engine turbojet airplane, the range of differences among the three measurement sites for a particular airplane category is small, being less than 1 dB. That the difference for the 3-727-200 airplane (Takeoff Procedure B) is consistently under that for 2-727-200 (Takeoff Procedure A of figure 3-5) shows that Takeoff Procedure B, sometimes referred to as a deep thrust procedure, not only provides significantly lower noise levels at the 5-C

Table 3-XIX Differences between mean EPNdB and mean peak dBA (EPNdB less dBA) for twenty-two airplane categories or groupings - takeoffs.

No.	Airplane Category	3-C EPNdB	3-C dBA	3-C diff	3-S EPNdB	3-S dBA	3-S diff.	5-C EPNdB	5-C dBA	5-C diff.
1	All airplanes	104.0	91.9	12.1	100.1	88.4	11.7	96.2	84.4	11.8
2	All 4-E NB*	107.0	93.8	13.2	103.7	90.4	13.3	98.4	85.7	12.7
3	All 4-E TF	107.1	93.3	13.8	103.4	89.6	13.8	98.2	84.8	13.4
4	All 4-E TJ	106.6	96.2	10.4	104.9	93.3	11.6	99.8	90.0	9.8
5	DC-8 TF	105.5	91.5	14.0	103.6	89.5	14.1	96.4	83.0	13.4
6	707 & 720 TF	109.1	95.4	13.7	103.1	89.7	13.4	99.8	86.5	13.3
7	707 TF	110.8	97.5	13.3	103.3	90.5	12.8	102.2	89.6	12.6
8	720 TF	106.0	91.6	14.4	102.4	87.4	15.0	96.8	82.6	14.2
9	All Wide Body	100.9	89.1	11.8	97.1	85.1	12.0	94.2	82.2	12.0
10	747	108.6	96.2	12.4	103.4	90.7	12.7	102.0	89.8	12.2
11	DC-10-10	97.1	84.3	12.8	94.0	82.1	11.9	90.1	77.6	12.5
12	DC-10-40	98.3	87.4	10.9	94.9	83.7	11.2	91.0	79.6	11.4
13	L-1011	99.2	87.4	11.8	94.6	82.6	12.0	92.4	80.4	12.0
14	DC-9 & 737	101.0	90.0	11.0	97.9	85.8	12.1	94.8	83.4	11.4
15	All 727	105.6	93.7	11.9	101.6	90.9	10.7	97.7	85.8	11.9
16	All 727-100	104.4	92.0	12.4	101.5	90.4	11.1	97.4	85.2	12.2
17	All 727-200	106.5	95.2	11.3	101.7	91.4	10.3	97.4	86.3	11.6
18	All 727-200†	106.4	94.5	11.9	102.3	91.9	10.4	100.4	88.6	11.8
19	1-727-200†	106.4	94.7	11.7	102.6	92.3	10.3	100.0	88.1	11.9
20	All 727-200††	106.6	95.6	11.0	101.4	91.1	10.3	96.7	85.2	11.5
21	3-727-200††	105.0	95.3	9.7	99.1	89.9	9.2	91.6	81.0	10.6
22	2-727-200††	107.9	95.8	12.1	103.8	92.4	11.4	101.0	88.7	12.3
	Mean of Differences			12.2			11.9			12.1
	S.D. of Differences			1.22			1.45			0.96
	Range			14.4 - 9.7			15.0 - 9.2			14.2 - 9.8

* Narrow Body = NB Turbofan = TF Turbojet = TJ 4-engine = 4-E

† No SAM †† With SAM

measurement site but also results in spectral changes over Takeoff Procedure A at all three measurement sites. Although the average constant difference between EPNdB and peak dBA is approximately 12 dB based on all airplanes, these results show that mean differences can range from 9 to 15

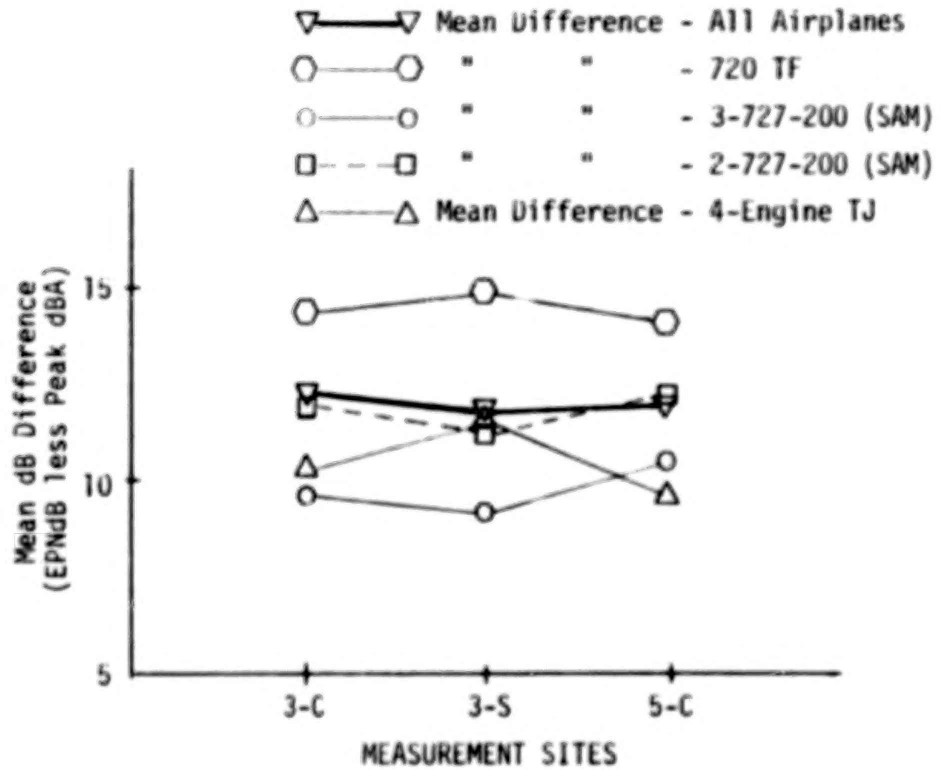


Figure 3-8. Mean differences (EPNdB less peak dBA) at three measurement sites for five airplane categories.

dB depending on airplane type, takeoff procedure, and receiver location.

The product-moment coefficient of correlation can also be used to evaluate the comparability between EPNdB and peak dBA as measures of response to flyover noise. Results based on this approach are given in Table 3-XX. The relationship between EPNdB and peak dBA is high at the 3-C measurement site which was directly under the flight path and near the airport, there is 89% common variance or commonality between the two measurement procedures. For the 3-S measurement position which is close-in to the airport but at sideline, commonality between the two procedures is 81%, leaving some 19% of the variance as error or attributable to

Table 3-XX Product-moment coefficients of correlation between EPNdB and peak dBA at the three measurement sites.

Measurement Site	Number of Events	Correlation Coefficient	% Common Variance
3-C	233	0.945	89%
3-S	234	0.900	81%
5-C	250	0.687	47%

other aspects between the two procedures which are different. However, at the 5-C site which is straight-out from the end of the runway and in that sense is under the flight path, the relationship between the two measures is relatively low. Variance common to the two procedures is 47% leaving more than 50% which is not in common to the two procedures. Using this method for evaluating comparability between the two procedures, it is clear that the greater the distance from the point of brake release, the greater the need for caution in interchanging the two calculation procedures.

Another approach relative to comparability between EPNdB and dBA as response measures involves their relative measurement variability. For a particular set of flyover measurements, does the EPNdB procedure provide more or less precision (variability) than the peak dBA procedure? Results concerning this question are obtained by examining differences between standard deviations for the two procedures using the twenty-two airplane categories of Table 3-XIX. Table 3-XXI provides a summary of this information for the three measurement sites.

For the 3-C measurement site, the dBA measurement procedure shows greater variability or less precision than does EPNdB. The difference between standard deviations for the two measures (dBA less EPNdB) is, with one minor exception, in the positive direction as the differences range from -0.01 to 0.93 dB for the twenty-two airplane categories. For the 3-S measurement site, EPNdB continues to show less variability or greater precision than peak dBA but not to the extent as at the 3-C measurement site. For five of the twenty-two airplane categories, EPNdB did show greater variability than peak dBA at 3-S. However, at the 5-C measurement site there is no difference in precision between the two measurement procedures. EPNdB shows greater variability than peak dBA for one-half of the twenty-two airplane categories. Close-in and under the flight path, EPNdB shows greater precision than peak dBA but at greater distances from the airport, precision for the two measurement procedures is identical.

Comparability between the two widely used airport noise exposure methods, NEF and L_{dn}, was not examined on the basis of the measured data. However, results based on state-of-the-art noise-thrust-distance data for four different fleet mixes are available at approximately 8.7 Km (4.7 n. miles) from brake release and at 1.0 Km (0.54 n. miles) to sideline. The four fleet mixes are representative of the years 1962, 1967, 1972, and 1975. For 1962, both 4-engine turbojet and turbofan aircraft were in use but more than one-half of the operations were by 3- and 4-engine piston-powered airplanes or 4-engine turboprops. For 1967, jet operations increased, including introduction of the 727, and operations from the

Table 3-XXI Mean, standard deviation (S.D.) and range of differences for S.D. of peak dBA less S.D. of EPNdB for twenty-two airplane categories.

	Measurement Sites		
	3-C	3-S	5-C
Mean	0.43	0.25	-0.12
Stand. Dev.	0.28	0.36	0.47
Range	-0.01 to 0.93	-0.46 to 1.19	-1.34 to 0.49

Table 3-XXII Comparison of computed NEF and L_{dn} for four different fleet mixes at a sideline measurement point.

	Fleet Mix			
	1962	1967	1972	1975
L_{dn}	71.2	73.4	68.7	67.8
NEF	32.6	36.5	33.9	33.0
L_{dn} - (NEF + 35)	3.4	1.9	-0.2	-0.2

larger piston-powered airplanes decreased. By 1972 and for 1975, jet operations completely dominated. Thus, on an average basis, there are three different acoustical or spectral groupings which are (1962), (1967), and (1972,75) Table 3-XXII provides the NEF and L_{dn} computed values for these four different fleet mixes. Both noise exposure methods show noise exposure peaking in 1967 and decreasing in 1972 and 1975. However, L_{dn} indicates that noise exposure was decreased in 1972 and 75 in comparison to 1962 while NEF points to a slight increase for 1972 and 75 over 1962. Differences between L_{dn} and NEF are plotted in figure 3-9 and show that there is high comparability between the two exposure methods for operations performed entirely by jet airplanes (1972 and 75) while comparability

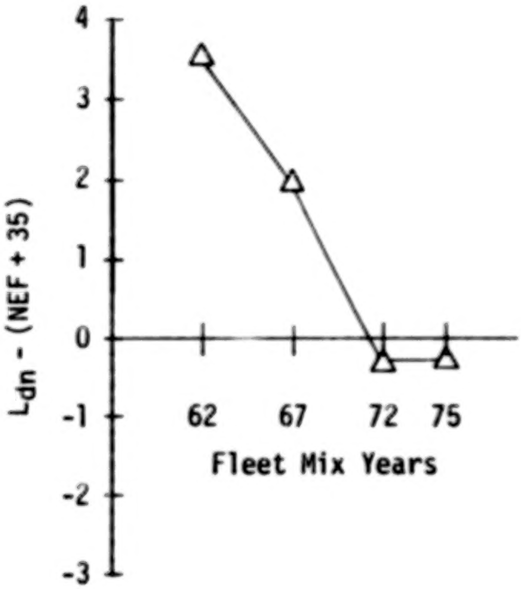


Figure 3-9 L_{dn} - (NEF + 35) for four different fleet mixes.

decreases as the proportion of piston-driven airplanes increases. This suggests high comparability of the two exposure methods at larger airports where jet operations clearly dominate but that much caution should be employed in interchanging the methods at airports where piston-driven and turboprop airplanes contribute to community noise exposure.

A final comparison of EPNdB and peak dBA involves the effectiveness of takeoff procedure B (Deep Thrust) over takeoff procedure A (In Route Climb) for the 727 airplane. Noise differences between the two takeoff procedures utilizing mean EPNdB and peak dBA are given in figure 3-10. Beginning with the results for the 727-200 (SAM) airplane (lower part of figure 3-9), at measurement site 3-C the mean peak dBA difference is zero while the difference at sideline (site 3-S) is approximately 2.4 dBA and

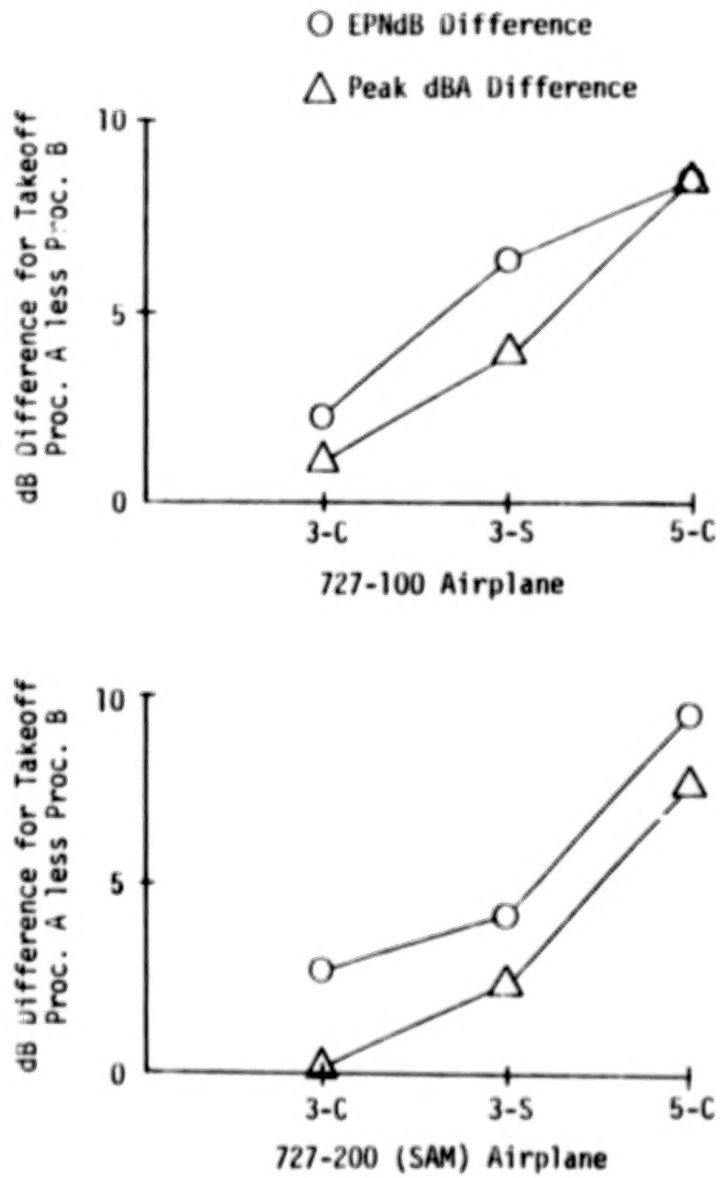


Figure 3-10. EPNdB and Peak dBA difference for takeoff procedure A (In Route Climb) less takeoff procedure B (Deep Thrust).

with a pronounced difference approaching 8 dBA at the 5-C measurement sites. Based on these peak dBA results, it could easily be concluded that the deep thrust procedure is not particularly effective at close-in-to-the-airport observer positions. However, if the EPNdB calculation procedure is used to compare the effectiveness of the two takeoff procedures for the 727-200 (SAM) airplane, the difference of almost 3 EPNdB at 3-C directly under the flight path and 4 EPNdB at sideline suggests that takeoff procedure B (Deep Thrust) begins noise reduction effects that could easily influence community noise annoyance at or before the 3-C observer position. Results based on the 727-100 airplane also support a conclusion that the EPNdB calculation procedure points to greater noise reduction benefits for takeoff procedure B close-in to the airport than does peak dBA (upper part of figure 3-10). As for the 727-200 airplane, there is greater noise reduction due to takeoff Procedure B (Deep Thrust) at sideline than under the flight path based on either calculation procedure but the difference of 6.4 EPNdB at site 3-S (sideline) in favor of takeoff procedure B indicates that the procedure may be unusually effective at sideline close-in to an airport. Thus, the calculation procedure utilized determines the degree of confidence in the effectiveness of takeoff procedure B at close-in observer positions.

4.0 SUMMARY OF RESULTS AND CONCLUSIONS

The preceding section provides a detailing of data, results, and some conclusions. Relative to describing noise environments to which some persons living around airports are exposed, evaluating noise prediction methodology, considering noise exposure reduction possibilities, and other application considerations, some results and conclusions are rated as more significant than are others. The aim of this section is to list such results and conclusions.

1. Persons living in areas around commercial aviation airports are exposed to a wide range of noise levels from jet-powered airplanes. Depending on the observer position, range of measured peak dBA levels varied from 27 to 33 dBA.

2. For takeoffs, the range of peak levels under the flight path is reduced at relatively greater distances from the airport and also at sideline in comparison to an under-the-flight-path position that is close-in to the airport.

3. An opposite effect was found for landings in that the range of peak levels is significantly greater at an observer position under the flight path at a greater distance from the airport and also at sideline when compared to the range of peak levels at an under-the-flight-path but close-in observer position.

4. For takeoffs close-in to the airport and under the flight path (5.63 Km or 3.04 n.miles from brake release), commercial jet airplanes can be classified into three main noise sets which are:

a. All 4-engine and 3-engine airplanes which have comparable noise levels and rank highest in mean peak dBA levels. Exceptions were the DC-8-61 and -62, and 720 turbofan airplanes which showed significantly lower noise levels.

b. All 2-engine turbofan airplanes which rank next highest in noise levels.

c. All 3-engine wide-body airplanes which are significantly quieter than the other two sets of aircraft.

5. For takeoffs close-in to the airport but at a sideline observer position (0.68 Km or 0.37 n. miles from centerline), commercial jet airplanes can be classified into four main noise sets which are:

   a. Four-engine turbojet powered airplanes with highest noise levels.

   b. All 4-engine airplanes which demonstrated next highest noise levels. Exceptions are the DC-8-62 and 720 turbofan airplanes which show significantly lower noise levels than other 4-engine airplanes.

   c. All 2-engine turbofan airplanes which are next to least quietest.

   d. All 3-engine wide-body airplanes which are the quietest of the four sets.

6. For takeoffs under the flight path but at a relatively greater distance from brake release (9.64 Km or 5.21 n. miles) there is no distinct pattern relative to mean peak dBA levels for the various categories of airplanes (see figure 3-3).

7. For landings at all three measurement sites, all 4-engine airplanes are significantly louder than the remaining jet powered airplanes. However, noise differences are less pronounced among the 3-engine wide-body, 3-engine narrow-body, and 2-engine narrow-body airplanes. For example, at the sideline observer position, mean peak dBA levels for 3-engine and 2-engine narrow-body airplanes are all less than those

for the 3-engine wide-body airplanes.

8. The deep thrust takeoff procedure resulted in significant noise reductions over the in route climb takeoff procedure for the 727-100 and 727-200 airplanes. As a means of significantly lowering noise exposure at commercial airports in the present time-frame, the deep thrust procedure could be unusually effective.

9. State-of-the art noise prediction technology for individual airplane categories can result in substantial differences when compared to measured results. For example, at the close-in under-the-flight-path measurement site, takeoff prediction was 14.0 dBA too high for the DC-8 turbojet airplane and 7.0 dBA too low for 747 airplanes.

10. On an average basis across all airplanes, state-of-the-art noise prediction technology under-predicts takeoff noise under the flight path and at sideline but to a slightly greater extent at sideline.

11. Average landing noise under the flight path is over-predicted by state-of-the-art noise prediction technology. However, at sideline, in comparison with measured results there is serious under-prediction with mean dBA differences ranging from 3 to 16 dBA.

12. Accounting for gross weight and slant range can increase measurement precision by 50-60% for some airplane categories.

13. There is some evidence that specific categories of airplanes can be flown with reduced ranges of noise levels. This suggests the possibility of reducing noise exposure by eliminating the higher level events such as those in the neighborhood of 5 to 10 dBA above the mean level.

14. The mean difference between EPNdB and dBA (EPNdB less dBA) for takeoffs averaged over all airplanes is 12 dB. However, for specific airplane types, the mean difference can range from 9 to 15 dB depending on takeoff procedure and receiver location.

15. The potential for interchangeability between EPNdB and dBA decreases as a function of distance from the airport.

16. Based on state-of-the-art noise prediction technology, there is evidence that NEF and L_{dn} are interchangeable ($L_{dn} = NEF + 35$) for fleets which are completely dominated by jet airplanes. However, if piston-driven and turboprop airplanes contribute to noise exposure, comparability between NEF and L_{dn} decreases as a function of the proportional contribution to noise exposure of these airplanes.

APPENDIX A

Standard deviations (S.D.) and standard errors of estimate (S.E.) for 22 airplane groupings are provided. Table A-I uses peak dBA as the noise measure while Table A-II uses EPNdB. "N" is the sample size on which the two measures are based. The results of Table 3-XVI in the text are based on these two tables. Table 3-XVI gives S.D. minus S.E. at the three recording sites for both peak dBA and EPNdB.

Table A-I Standard deviations (S.D.) and standard errors of estimate (S.E.) in peak dBA for twenty-two airplane groupings.

No.	Airplane Category	3-C			3-S			5-C		
		N	S.D.	S.E.	N	S.D.	S.E.	N	S.D.	S.E.
1	All airplanes	233	5.22	4.78	234	4.67	4.14	250	5.19	4.98
2	All 4-E NB*	46	5.09	3.73	40	3.53	2.55	46	4.75	3.44
3	All 4-E TF	37	5.39	3.61	31	3.18	2.23	38	4.65	2.39
4	All 4-E TJ	9	2.74	2.72	9	3.31	1.58	8	2.39	2.18
5	DC-8 TF	20	5.26	4.18	16	3.11	2.41	18	3.66	2.40
6	707 & 720 TF	17	4.86	2.33	15	3.36	1.98	20	4.90	2.20
7	707 TF	11	3.96	1.60	11	3.55	1.44	11	3.93	2.04
8	720 TF	6	4.08	3.30	4	1.16	1.20	9	2.68	1.10
9	All Wide Body	81	5.55	3.41	86	4.52	2.78	84	5.90	2.38
10	747	23	4.07	3.38	24	2.94	2.34	25	4.27	2.07
11	DC-10-10	21	2.80	2.38	21	2.68	2.02	22	2.34	1.34
12	DC-10-40	32	2.50	2.50	34	3.09	3.01	30	2.58	1.74
13	L-1011	5	1.40	0.92	7	1.77	1.35	7	0.37	0.37
14	DC-9 & 737	14	1.40	1.21	13	1.85	1.59	17	1.97	1.90
15	All 727	92	4.01	3.21	95	3.36	2.86	102	4.36	3.72
16	All 727-100	41	3.65	3.41	43	2.64	2.47	43	4.08	3.43
17	All 727-200	51	3.75	2.62	52	3.82	2.88	59	4.53	3.74
18	All 727-200†	19	2.02	1.95	19	2.16	1.56	20	1.95	1.71
19	1-727-200†	15	2.13	2.11	15	2.02	1.23	16	1.67	1.69
20	All 727-200††	32	4.46	2.97	33	4.51	3.37	39	5.04	3.70
21	3-727-200††	15	4.70	[illegible].94	17	5.17	2.87	18	3.32	2.01
22	2-727-200††	17	4.38	1.85	16	3.37	2.24	21	3.16	2.74

* Narrow Body = NB Turbofan = TF Turbojet = TJ 4-engine = 4-E

† No SAM †† With SAM

Table A-II Standard deviations (S.D.) and standard errors of estimate (S.E.) in EPNdB for twenty-two airplane groupings.

No.	Airplane Category	3-C			3-S			5-C		
		N	S.D.	S.E.	N	S.D.	S.E.	N	S.D.	S.E.
1	All airplanes	233	5.08	4.84	234	4.62	4.39	250	6.53	5.43
2	All 4-E NB*	46	4.34	3.25	40	2.87	2.12	46	4.39	2.33
3	All 4-E TF	37	4.69	3.50	31	2.81	2.11	38	4.61	1.89
4	All 4-E TJ	9	2.65	2.25	9	2.90	1.87	8	3.04	2.44
5	DC-8 TF	20	4.72	4.04	16	2.87	2.05	18	4.18	2.07
6	707 & 720 TF	17	3.93	2.18	15	2.82	1.98	20	4.45	1.61
7	707 TF	11	3.08	1.53	11	3.22	1.73	11	3.69	1.44
8	720 TF	6	3.58	3.02	4	1.30	0.66	9	3.46	1.50
9	All Wide Body	81	5.56	3.10	86	4.72	2.82	84	5.93	2.26
10	747	23	3.73	2.83	24	2.51	2.10	25	4.33	1.56
11	DC-10-10	21	2.34	2.29	21	1.91	1.02	22	2.16	1.11
12	DC-10-40	32	2.24	2.24	34	3.11	2.96	30	2.24	1.58
13	L-1011	5	1.22	0.92	7	1.42	1.33	7	0.78	0.72
14	DC-9 & 737	14	0.75	0.60	13	1.40	1.11	17	1.48	0.96
15	All 727	92	3.51	2.98	95	3.47	3.22	102	4.65	3.98
16	All 727-100	41	3.17	3.01	43	3.10	2.76	43	4.11	3.48
17	All 727-200	51	3.54	2.39	52	3.77	3.31	59	5.04	4.05
18	All 727-200†	19	1.52	1.52	19	2.02	1.74	20	1.96	1.66
19	1-727-200†	15	1.69	1.69	15	1.96	1.70	16	1.56	1.53
20	All 727-200††	32	4.34	2.74	33	4.48	3.89	39	5.65	3.93
21	3-727-200††	15	4.70	2.41	17	4.92	2.82	18	3.06	1.06
22	2-727-200††	17	3.62	1.80	16	2.18	1.68	21	3.04	2.55

* Narrow Body = NB   Turbofan = TF   Turbojet = TJ   4-engine = 4-E

† No SAM   †† With SAM

APPENDIX B

The product-moment coefficients of correlation between peak dBA vs gross weight or slant range and EPNdB vs gross weight or slant range are provided in Tables B-I, B-II, and B-III. Since noise levels should increase as gross weight increases, correlations between the two noise measures and gross weight should be positive. However, since noise levels decrease as slant range increases, the correlations between noise measures and slant range should be negative.

Table B-I Site 3-C product-moment coefficients of correlation.

Airplane Category	Peak dBA			EPNdB		
	GW	SR	Log SR	GW	SR	Log SR
All airplanes	-.077	-.230	-.265	-.074	-.133	-.152
All 4-E Narrow Body	.498	-.652	-.677	.491	-.603	-.642
All 4-E Turbofan	.628	-.692	-.732	.511	-.605	-.646
All 4-E Turbojet	.180	-.349	-.377	.293	-.594	-.605
DC-8 Turbofan	.345	-.464	-.534	.162	-.310	-.378
707 & 720 Turbofan	.879	-.869	-.859	.844	-.813	-.810
707 Turbofan	.924	-.841	-.844	.892	-.745	-.772
720 Turbofan	.590	-.690	-.675	.508	-.689	-.649
All Wide Body	.792	-.410	-.487	.832	-.384	-.456
747	.526	-.553	-.595	.553	-.668	-.672
DC-10-10	-.400	.119	.056	-.229	.052	.000
DC-10-40	.171	-.166	-.151	.190	-.086	-.077
L-1011	.456	-.062	-.063	.756	-.604	-.603
DC-9 & 737	.558	-.191	-.118	.446	.161	.235
All 727	.561	-.545	-.556	.536	-.398	-.403
All 727-100	.052	-.218	-.268	.008	-.244	-.193
All 727-200	.684	-.568	-.583	.742	-.368	-.390
All 727-200 (No SAM)	.294	-.335	-.335	.100	-.105	-.108
1-727-200 (No SAM)	.230	-.285	-.288	.099	-.082	-.090
All 727-200 (SAM)	.709	-.617	-.627	.784	-.426	-.446
3-727-200 (SAM)	.798	-.424	-.432	.870	-.401	-.425
2-727-200 (SAM)	.698	-.878	-.905	.777	-.837	-.861

Table B-II Site 3-S product-moment coefficients of correlation.

Airplane Category	Peak dBA			EPNdB		
	GW	SR	Log SR	GW	SR	Log SR
All Airplanes	-.266	-.282	-.303	-.195	-.186	-.202
All 4-E Narrow Body	.386	-.670	-.691	.407	-.658	-.678
All 4-E Turbofan	.597	-.653	-.685	.501	-.616	-.647
All 4-E Turbojet	.728	-.894	-.889	.725	-.803	-.787
DC-8 Turbofan	.572	-.611	-.645	.650	-.666	-.702
707 & 720 Turbofan	.655	-.801	-.804	.506	-.735	-.730
707 Turbofan	.584	-.926	-.903	.509	-.860	-.828
720 Turbofan	-.184	.499	.536	.879	-.012	-.004
All Wide Body	.776	-.374	-.392	.795	-.349	-.362
747	.328	-.628	-.618	.101	-.591	-.575
DC-10-10	.587	-.569	-.559	.665	-.750	-.742
DC-10-40	.300	-.250	-.258	.353	-.299	-.280
L-1011	.541	.640	.625	.512	.300	.282
DC-9 & 737	.538	-.511	-.512	.557	-.633	-.627
All 727	.298	-.520	-.534	.166	-.381	-.379
All 727-100	-.020	-.386	-.364	-.168	-.392	-.366
All 727-200	.386	-.625	-.633	.376	-.421	-.425
All 727-200 (No SAM)	.036	-.697	-.720	-.086	-.502	-.534
1-727-200 (No SAM)	.199	-.798	-.810	.031	-.542	-.566
All 727-200 (SAM)	.443	-.635	-.639	.445	-.425	-.423
3-727-200 (SAM)	.630	-.799	-.812	.683	-.773	-.772
2-727-200 (SAM)	.260	-.767	-.757	.256	-.669	-.666

Table B-III Site 5-C product-moment coefficients of correlation.

Airplane Category	Peak dBA			EPNdB		
	GW	SR	Log SR	GW	SR	Log SR
All Airplanes	-.011	-.250	-.264	.076	-.038	.238
All 4-E Narrow Body	.520	-.693	-.699	.681	-.833	-.840
All 4-E Turbofan	.770	-.800	-.844	.787	-.871	-.893
All 4-E Turbojet	.299	-.538	-.536	.507	-.648	-.671
DC-8 Turbofan	.476	-.758	-.771	.551	-.873	-.877
707 & 720 Turbofan	.881	-.848	-.873	.912	-.885	-.910
707 Turbofan	.726	-.870	-.866	.825	-.920	-.929
720 Turbofan	.924	-.638	-.655	.910	-.765	-.782
All Wide Body	.902	-.663	-.715	.920	-.627	-.686
747	.643	-.880	-.869	.705	-.935	-.934
DC-10-10	.776	-.668	-.654	.806	-.754	-.760
DC-10-40	.639	-.736	-.741	.691	-.646	-.662
L-1011	-.236	.115	.104	-.174	.547	.536
DC-9 & 737	.327	-.108	-.057	.557	-.126	-.039
All 727	.328	.105	.131	.277	.144	.179
All 727-100	.122	.185	.241	.134	.090	.152
All 727-200	.411	.202	.206	.389	.263	.267
All 727-200 (No SAM)	.447	-.367	-.358	.442	-.444	-.445
1-727-200 (NO SAM)	.180	-.237	-.206	.067	-.319	-.293
All 727-200 (SAM)	.504	.198	.179	.478	.276	.256
3-727-200 (SAM)	.743	-.766	-.789	.796	-.928	-.935
2-727-200 (SAM)	.538	-.541	-.550	.578	-.467	-.479

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Final Report

16. Abstract

The data base for a commercial airport noise measurement program included approximately 1,100 calibrated tape recordings at three observer positions and some 1500 supplementary peak level measurements at ten additional measurement points. For some individual airplane categories, there were substantial differences between results based on state-of-the-art noise prediction technology and those based on actual measurements. Certain takeoff procedures resulted in significant noise reductions for particular airplane types. Also, there was some evidence that specific categories of airplanes can be flown with reduced ranges of peak noise levels.

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